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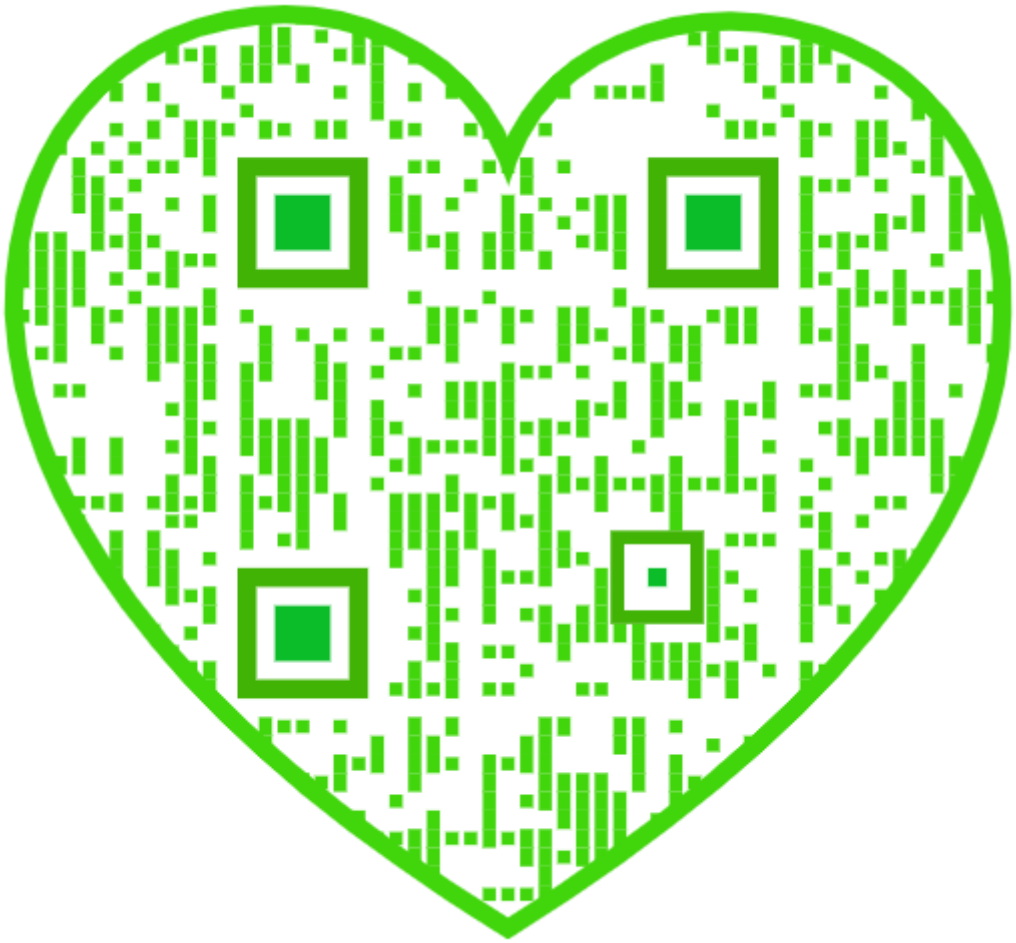

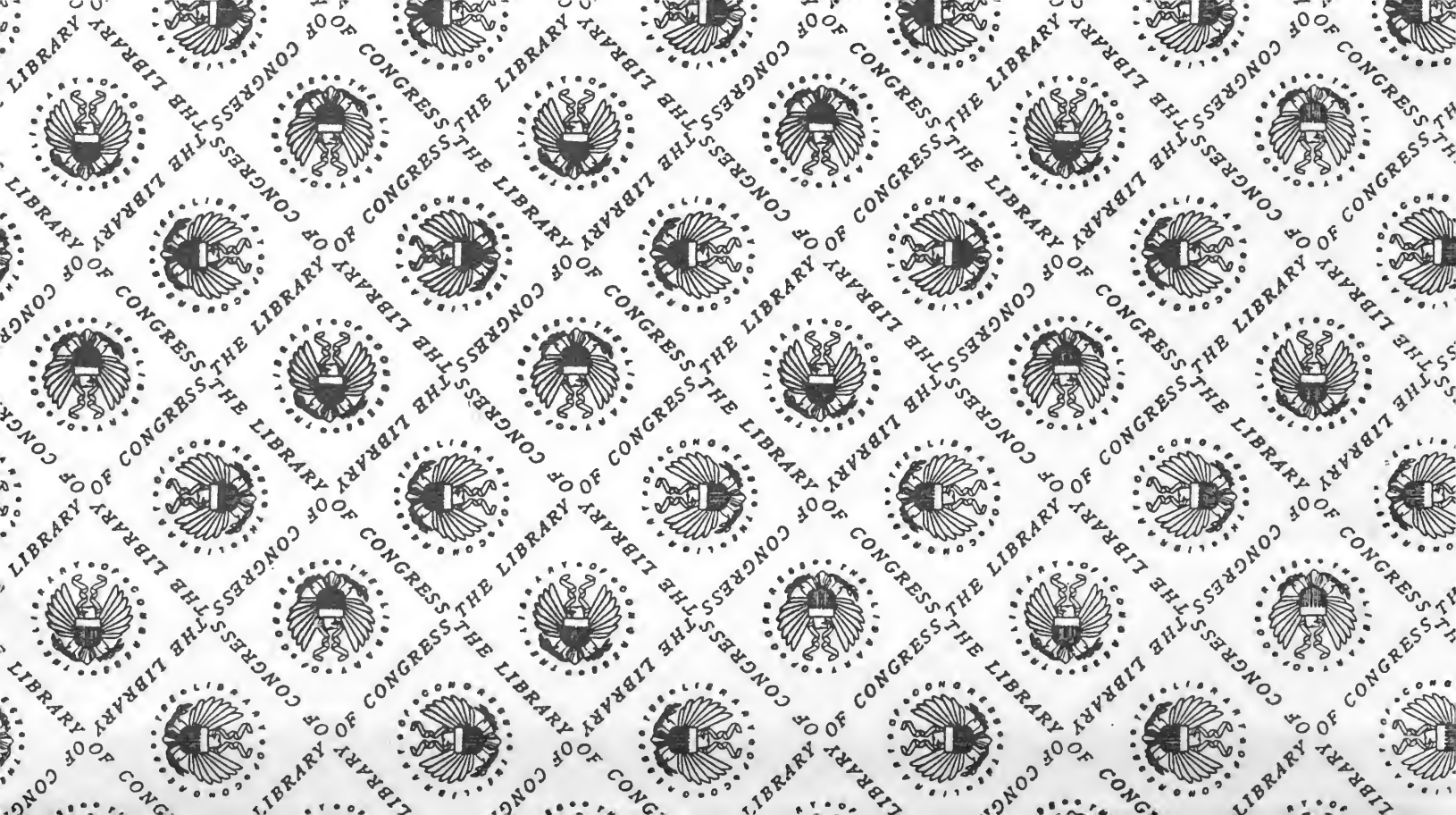
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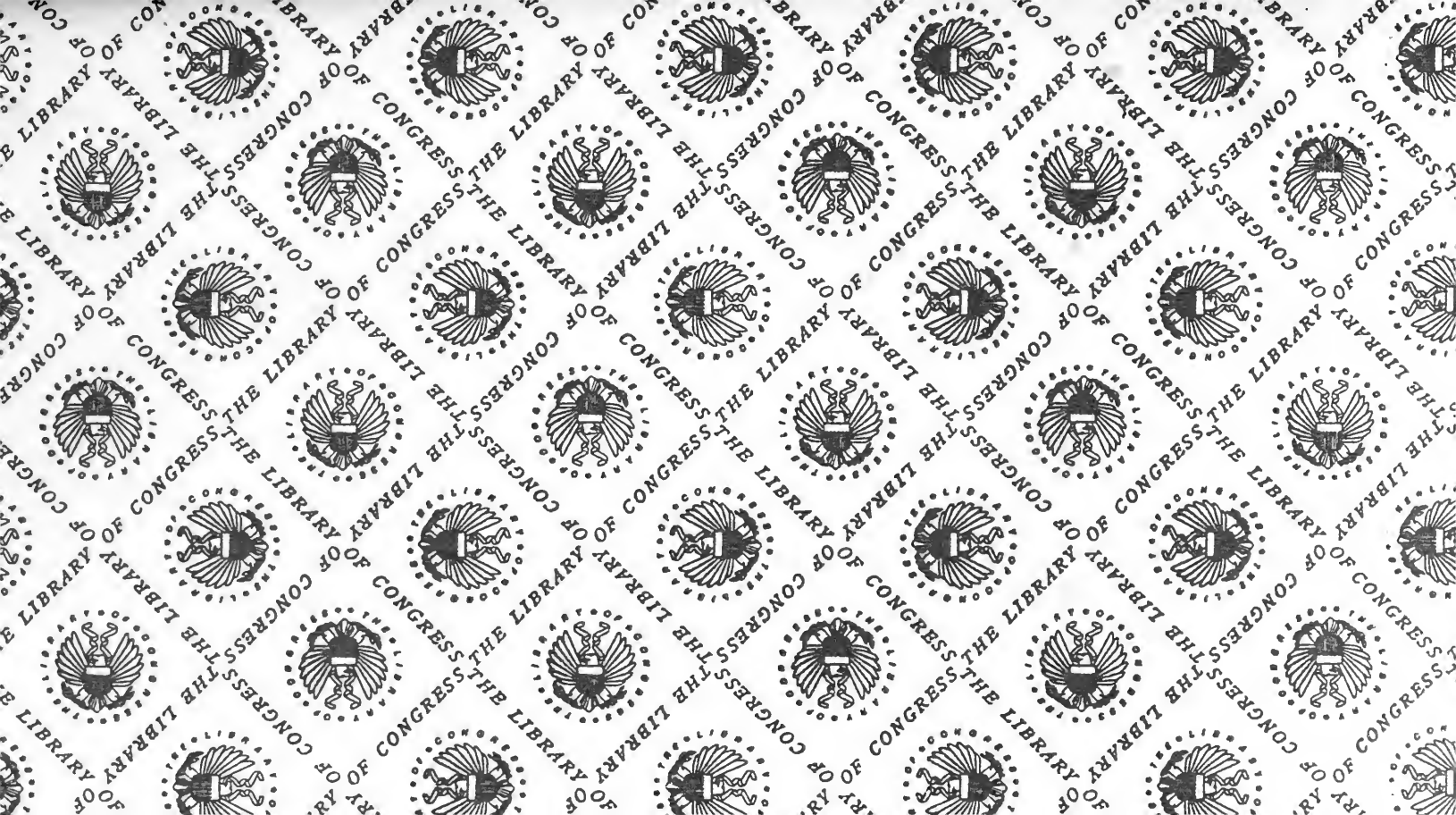
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Mr. _____

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PREFACE

This hand book is written with the object of enabling every manufacturer to train his employees in the method of drying lumber by the Vapor Process, that he may have the positive assurance that when the instructions are carefully followed, the results will be as positively uniform. The tables and plates are from actual experience. They are never exactly reproduced, even under similar circumstances, but the results are very uniform.

The principal elements in the successful working of a kiln are heated air and steam vapor.

The Ventilation is directly opposite to natural atmospheric conditions; in other words, cold air will rush into a room, if there is an opportunity for the hot air to escape, but in this process the cold air is taken into warm flues, heated and delivered to the upper portion of the room.

The amount of warm air supplied is regulated by the amount of cold, damp, vitiated air which is being removed from the bottom of the kiln by the use of ducts connected at the base of the stacks.

The force with which this circulation is produced depends upon the expansion of the moisture coming from the spray and the lumber, intensified by the use of heating pipes in the stacks, which become reservoirs of compressed hot air by the use of the compression caps or dampers.

Under this system of ventilation it is possible to empty the entire cubic contents of air in any specified time desired, depending upon the amount of moisture contained in the lumber, and the time desired to dry it, thus showing that the process of drying is reduced to a problem in mathematics.

This process is not confined to use in new kilns, but may be successfully applied in old kilns properly remodeled.

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INTRODUCTION

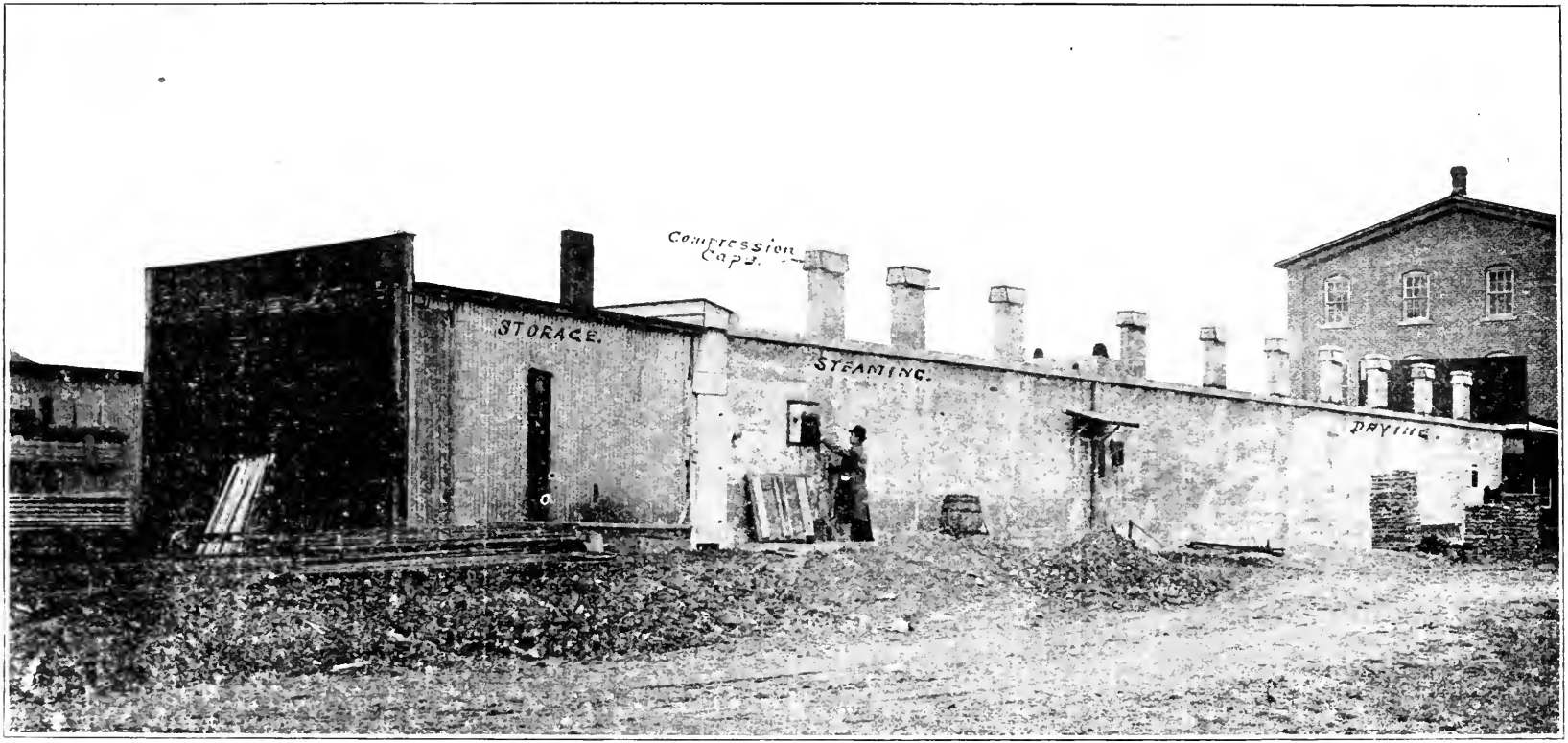
Presenting these Dry Kiln instructions for the drying of lumber, in the varied forms of manufacture, which the great variety of woods from our forests are producing, is no small task. It is a well known fact that the raw material is cut into more than 100 thicknesses from 1″ up to square timber, which represent the full product of a single log. It is also known that in air drying this stock from the saw or cutting machine, it is subject to great loss not only from contact with the atmosphere, but from mould, bluing, sun checking and warping. It has been our aim to arrest these destructive elements which degrade the quality of the lumber, and make a great amount of extra handling. This in many cases produces great losses from shrinkage of valuations, besides requiring a vast amount of money being tied up in raw material.

The object in view was to get a process which would be capable of handling the stock direct from the log and drying it for immediate use, making it possible to eliminate the lumber yards at the factories and mills. This necessitated the remodeling of a kiln that was equipped with Direct Radiation system of heating, requiring 20 to 30 days to dry 4-4 oak, with highly rarified air.

The construction of buildings for dry kiln purposes varies as greatly as does the material to be dried. and the arrangement of the mechanical apparatus is as varied as the chemical results. During our experimental work, it was found, after much time and money had been spent, that humidity was as essential as the heated air.

When the percentage of humidity was finally worked out, to a tabulated system, there was no difficulty in drying 4-4 oak in seven days, with the same kiln building, by a rearrangement of heating pipes and ventilation. When kilns are especially designed for special work, the results are even greater; the most phenominal being the successful drying of air dried maple shoe last blocks in the short time of 23 days, using low pressure exhaust steam during working hours only, and no steam on Sundays.

We invite careful study of the Operating Instructions, with accompanying tables, which show the variable conditions in temperatures and humidities carried. In operating kilns equipped with this process, it is only necessary to reproduce as nearly as possible the kiln record which applies the nearest to the kind of lumber desired to be dried.



Progressive Kiln

CHAPTER I.

PROGRESSIVE KILN INSTRUCTIONS

For Drying 1" Hardwood Lumber

1. The drying of lumber by the progressive kiln process consists of:

   First — Exposing the lumber to the direct action of steam intermingling with the lumber;

   Second — Gradually displacing the steam with dry heat from the heating coil;

   Third — Gradually or progressively moving the lumber forward to the unloading end of the kiln with the heat growing more intense and the humidity growing less as the lumber approaches the unloading end of the kiln.

   Fourth — The removing of the damp or vitiated air from the bottom of the kiln by a system of ventilation flues.

2. SETTING BUNKS. To avoid friction and to produce easy running cars, set each bunk with the left-hand flange of the wheels against the side of the Tee rail. This will insure perfect alignment of each, and the moment the car is started forward it will equalize itself upon each rail.

3. PLANK BASE FOR LOAD. Place five 2" x 8" planks, or their equivalent, on top of the several bunks, as shown in Fig. 1, to provide a substantial base on which to load lumber, and if these planks become bent in service, always place the crowning side up so that the load may bring them back to a straight line. This will preserve the plank and assist in producing a good flat foundation for carrying a heavy load.

4. PILING STICKS. The piling sticks used should be sized to an even thickness, $\frac{13}{16}$", $\frac{7}{8}$", or 1⅛"x1½" or 2", and when loads run over 10' high, the 1⅛"x2" piling sticks should be used. In placing the piling sticks, be careful that they are located over the center of each bunk, as in Fig. 2, and also that one piling stick is placed between each bunk, and one

at each end of the load, each stick directly over the other, except, when the lower plank bed is shorter than the length of the load when the sticks should be carried from the bunks upon an incline from the perpendicular, as shown in Fig. 2.

5. LOADING THE LUMBER ON THE CAR. Place the first five courses two-thirds lumber and one-third open space to admit the heat to the center of the load, gradually closing the spaces until they are nearly closed at the top of the load. Pile the loads up square at the ends to the full length of the longest lumber, no matter how short the lumber comes, alternating the even ends to each end of the car, as shown in Fig. 2. When the load is finished put small blocks where lumber may have been left out in piling. These are readily procured from the cuttings at cut-off saw. This form of piling is no more expensive than the usual method and insures the lumber coming out straight, and will pay handsome profits to the manufacturer who insists upon it.

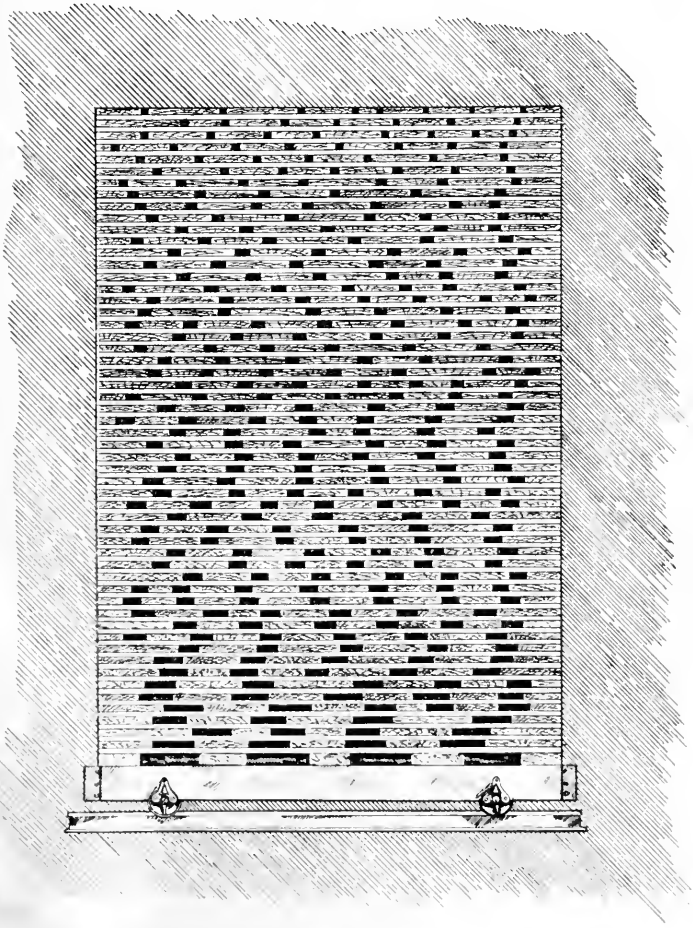


Fig. 1

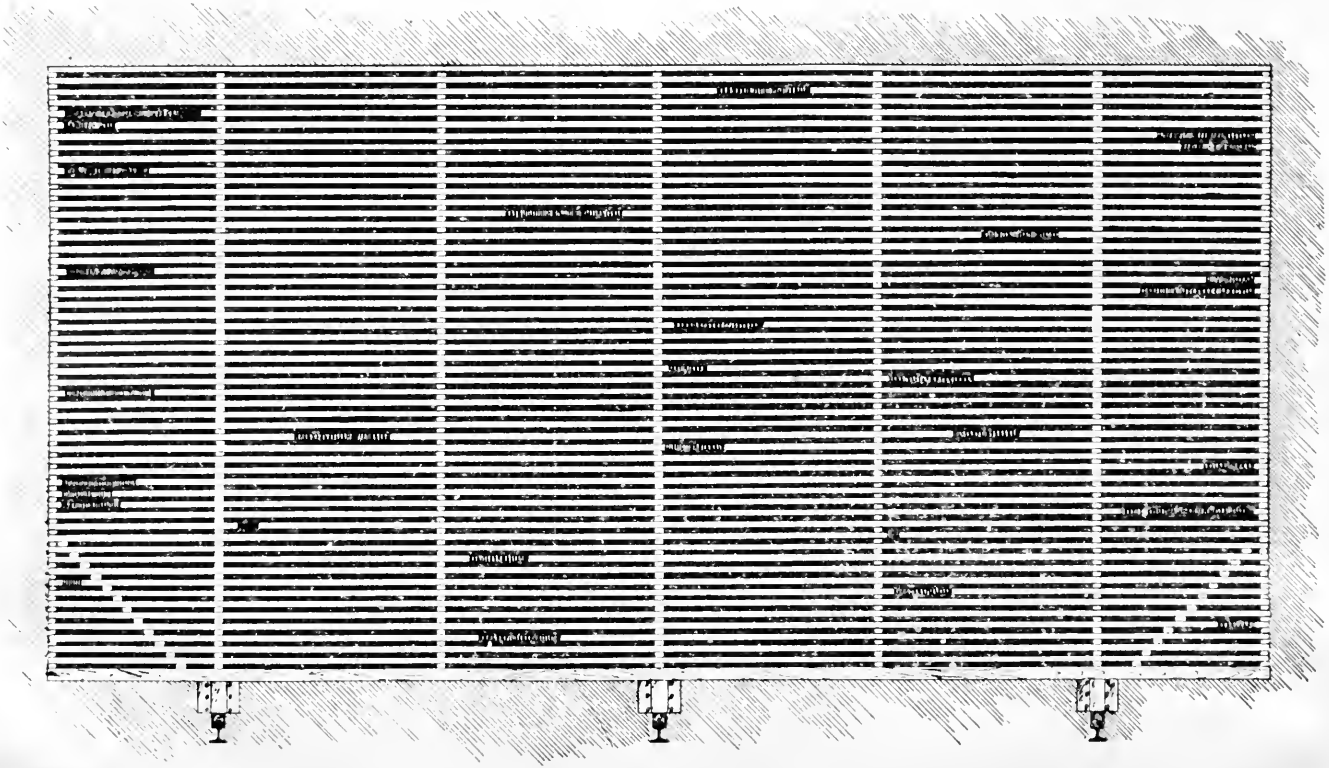


Fig. 2

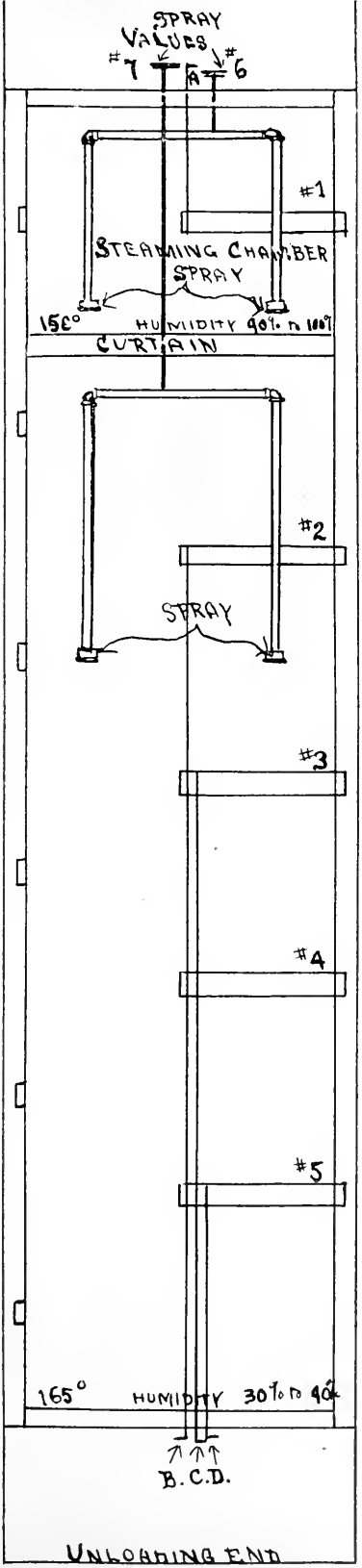

SPRAY VALVES
#7
#6
#1
STEAMING CHAMBER
SPRAY
150°
HUMIDITY 90% to 100%
CURTAIN
#2
SPRAY
#3
#4
#5
165°
HUMIDITY 30% to 40%
B.C.D.
UNLOADING END

Fig. 3

6. PLACING THE CARS IN THE KILN. Place test sticks on each car. (See Dry Test suggestions, page 32). See that the inner curtain is down to place tightly, before closing the kiln. If possible, put fresh cars in the kiln in the morning, spraying with exhaust steam so that the spray may be turned off during the night. When lumber enters the kiln it is comparatively dry, and must be sprayed strongly with steam at a temperature of about 140 deg. Fahr. until the hygrodeik shows a relative humidity of from 80% to 100%, to complete saturation, or as damp as possible without staining the lumber at the piling sticks. Close all the outlet dampers and doors of the kiln as tightly as possible. The heat on the coils being continuous, (the usual temperature ranging from 140 deg. at the loading end, to 165 deg. at the unloading end,) it is necessary to immediately turn on the full amount of steam spray, to moisten the lumber before it can be made hot by the heat from the coils, which will give from 80% to 100% humidity. See that the spray valve is set to maintain the volume of steam so that the humidity will remain close to 100%. The temperature on the thermometer will show a quick rise, but keep the spray on sufficiently to maintain the humidity. During the second twenty-four hours, the temperature will free the moisture from the lumber itself, and this will help to keep up the necessary humidity. It is essential that the lumber produce as much of this humidity as possible; therefore, this quick high temperature makes it necessary to carry great humidity in the steaming chamber.

7. THE STEAMING CHAMBER. Never move all of the cars forward unless they are cars of lumber that will dry in one-half the time of hardwood, and only demand 24 hrs. steaming. Thicker stock will need a longer period of steaming, this to be in proportion to the time it takes to dry this stock as compared with seven day stock (i. e., 2″ in 4 days and 3″ in 6 days).

8. CAUTION! BEFORE MOVING THE LUMBER FROM THE STEAMING CHAMBER. The operator should have a Test Gauge Stick on one board in every car (see Dry Test Suggestions, pages 32-38), to note the expansion in the steaming chamber, as he can by this method bring all kinds of lumber much closer to a uniform treatment than by any other method.

9. STARTING THE CARS FORWARD. When the car is ready to move forward and enter the main body of the kiln, keep it close to the middle curtain,

allowing it to go forward only as other cars, entering from day to day, push it forward. Should a car that is damp and steaming be sent directly to the dry end of the kiln, it would case harden at once.

10. CARS COMING INTO MAIN KILN. As the cars enter the main apartment of the kiln, it is necessary to raise the humidity in this apartment to 40 per cent or more, at the unloading end, and this should be carefully attended to each time cars are sent forward. When the kiln is nearly filled and cars are near the unloading end, 30 or 40% humidity should be maintained.

11. TO KNOW HOW TO SET DAMPERS AT ANY TIME. Damper rods B, C and D, see Fig. 3, are located at the unloading end of the kiln. Keep these dampers closed until the kiln is half full of lumber, when damper B should remain closed, C one-quarter open and D one-half open. Should the humidity become too great at the unloading end, open C. Should the humidity drop too low, then reduce the openings of the dampers. Damper rod B is operated only when the stock is excessively moist.

12. STACK EQUALIZER. (See Plate XI). The draught in the stacks should be controlled by the amount of heat in the flues. To operate it to its fullest capacity requires steam heating to pipes in the stack, and open dampers; and to retain the humidity, the dampers should be partly closed, or the heat of the pipes reduced—possibly both. When these are both adjusted to the requirements of each kiln, there is scarcely any further need of adjusting or opening or closing of the dampers. Do not allow the draught through the stacks to be strong enough to reduce the temperature in the kiln. Keep the equalizers hot—a dead stack lets cold air into the kiln and checks the lumber.

13. DUCTS TO STACKS. (See Plate IX). Ducts are placed at intervals on the bottom of the kiln to remove the acids and vitiated air, and are controlled by dampers. After a little experience in setting the valves and dampers, the heat in the kiln will regulate the amount of discharge from the stacks, and the operator will have complete control.

14. FRESH AIR INLETS. (See Plate VIII). Fresh air flues should be so placed as to provide the necessary fresh air for renovating the kiln. The operating of the kiln being an eliminating or exhaust process, it is necessary to allow a sufficient vent to keep the stacks constantly drawing from the bottom of the kiln. Occasionally when there is an excess of

humidity in the kiln, the damp air will be ejected through the fresh air supply. If this is caused by putting in too much steam spray, reduce the opening of the spray valve. (See Fig. 3, No. 6). If the moisture is being expelled from the lumber, open the stack dampers in the center of the kiln a trifle more, and the stacks will draw this moisture from the bottom of the kiln.

15. KILN FILLED. Keep putting in the lumber and steaming as directed. Keep in mind that the humidity is what keeps the outside of the lumber soft, while the moisture is being drawn from the center of the lumber, and allowed to escape. Now, when the lumber is soft, if there are plenty of piling sticks of uniform thickness, it will straighten out and dry straight. Whenever it is possible, allow the lumber to cool on the cars 24 hrs. before unloading it. It is better and it will pay to do so.

16. DEAD PILING. Lumber kept in storage should always be tested before going to the factory, as many times there is great difference between the stock taken from the bottom and from the top of the pile.

17. DELAYS. Should the kilns have to be cooled down for Sunday, holidays or other causes, be sure and increase the sprays of steam on both chambers until the humidity is brought back to normal condition throughout the kiln and adjust the sprays to keep this percentage of humidity. As soon as the moisture begins to evaporate from the lumber, causing a rise in humidity faster than the stacks can carry it off, open the dampers as much as possible without lowering the temperature.

18. CARS REMAINING IN THE KILN. When dry lumber is accumulating so that the cars cannot be removed from the kiln when dry, reduce the temperature, but retain the percentage of humidity or run the kiln during the day only, beginning every morning by starting the sprays at both ends of the kiln, the same as though the kilns had been opened for moving the cars forward. If the kiln is sufficiently tight, the humidity may be retained by partly closing the dampers, but do not shut off the discharging of the foul air entirely, at any time.

19. THICK STOCK. When cars of thick stock are run through the kiln with cars of thinner stock, arrange the trucks or transfers so that the thick stock may be run out, and allow the thinner stock to be removed, and then return the thicker stock to the kiln. In this manner the thicker stock may be dried with-

out unloading or making any delay in getting out the thinner stock. When there is only an occasional car of thick stock, these cars may be loaded with a few cars of thinner stock between them so that they will not interfere with the daily supply of lumber. (See kiln records for further illustrations).

The kinds of 1″ lumber that may be in the steaming chamber together and steam 24 hours.

Ash, Basswood, Cherry, Elm (grey), Pine and Poplar.

Kinds requiring 48 hours steaming.

Beech, Birch, Chestnut, Elm (rock), Maple and Oak.

For White Maple and White Basswood, see kiln record number five.

Chestnut or Oak should not be placed in the steaming chamber with light colored woods, as they contain a great amount of tanic acid, and this will darken the very light woods, which is very damaging when white stock is desired.

STEAMING CHAMBER

Operated as a Box Kiln

For a Hurry Up Job of Drying

When the Drying Chamber is full of lumber of various thicknesses, it often retards the work of entering cars into the steaming chamber, and often there is great need of drying some special stock that can be dried in 24 or 48 hours.

Under this method of operating progressive kilns, it makes it an easy matter to put this special stock into the steaming chamber and operate it as an independent box kiln. This method of drying is fully explained in Chapter II.

The accompanying kiln records are designed to show as clearly as possible the great variety of work done; the way the valves and dampers are set, with the time, showing the temperatures and the percentages of humidity carried.

Record No. 1, is for 4-4 Oak 12 months stock, lumber piled crosswise of the kiln. The time in the steaming chamber and setting of valves and dampers is shown for this time. Then the transfer to the drying chamber commences and this record is kept independent of the steaming chamber to the end of the time of drying the stock.

KILN RECORD

Kind of Wood ... OAK Address _____

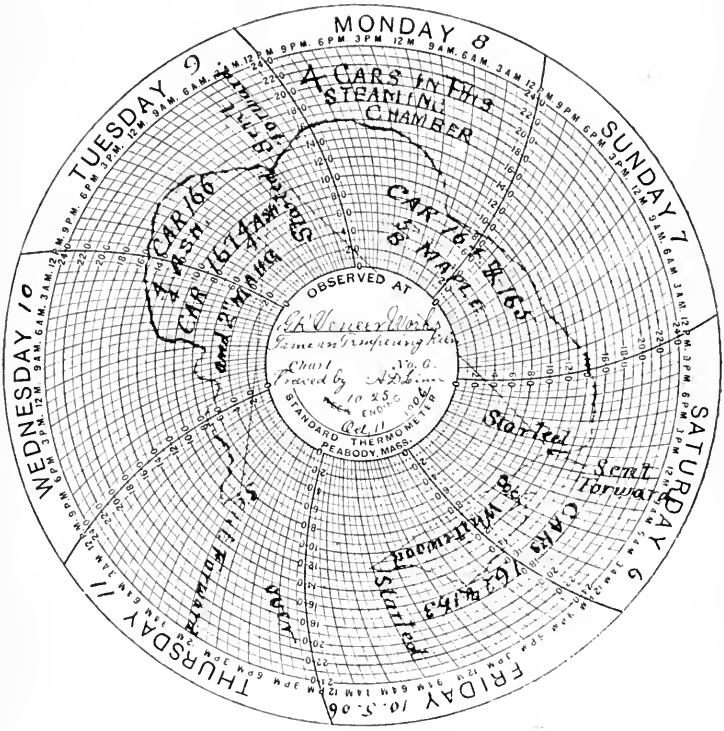
Thickness 4/4

Age ..... 12 MO & OLDER

TIME TEST WAS MADE	LOADING END							UNLOADING END					
	SPRAY	COIL	DAMP AIR	FRESH AIR	WET BULB	DRY BULB	PER CENT HUMIDITY	SPRAY	DAMP AIR	FRESH AIR	WET BULB	DRY BULB	PERCENT HUMIDITY
A.M.	2	F	0	0	80	80							
P.M.	"	"	"	"	118	120	95						
A.M.	"	"	"	"	128	130	92						
P.M.	"	"	"	"	138	140	95						
A.M.	"	"	"	"	"	"	"	1/4	1/4	1/4	128	145	60
	car advanced												
P.M.	"	"	"	"	139	"	98	"	"	"	126	"	55
A.M.	"	"	"	"	140	142	93		"	"	127	150	50
P.M.	"	"	"	"	"	140	100		"	"	130	152	52
A.M.	"	"	"	"	133	135	"		1/4	F	128	155	45
P.M.	"	"	"	"	142	145	92		"	"	"	158	42
A.M.	"	"	"	"	138	140	95		F	"	"	160	40
P.M.	"	"	"	"	144	145	96		"	"	"	"	"
A.M.	"	"	"	"	143	"	95		"	"	125	162	32
P.M.	"	"	"	"	140	142	"		"	"	128	165	30

Kiln Record No. 1

The following Recording Thermometer Record shows seven day drying of 4-4 oak but by different fire than above kiln record.



The above diagram compared with the foregoing kiln record No. 1, shows the drying of 4-4 oak in seven days.

The lumber was placed in the steaming chamber at 9:00 A. M. on Wednesday and remained until Saturday noon when it was passed into the drying chamber and remained until 7:00 A. M. the following Wednesday.

(This chart is read from Wednesday down and to the right).

PROGRESSIVE KILN RECORD

Kind of Wood WHITE OAK Address

Thickness 2"

Age 12 MO.

	LOADING END								UNLOADING END				
TIME TEST IS MADE	SPRAY	COIL	DAMP AIR	FRESH A.	DEGREES WET BULB	DEGREES DRY BULB	PERCENT HUMIDITY	SPRAY	B. DAMP C. A. D.	FRESH A.	WET BULB	DRY BULB	PER CENT HUMIDITY
7.30 A.M.	3	2	0	0	110	115	85	2	B-0	F	108	135	40
Car entered 8.00	"	"	"	"	117	120	90	0	C-0	"	112	140	40
5.30 P.M.	"	"	"	"	120	122	92	"	D-0	"	113	142	40
7.30 A.M.	"	"	"	"	125	125	100	"	R-0	"	113	145	42
	"	"	"	"	125	125	100	"	C-0	"	113	145	42
5.30 P.M.	0	2	"	"	125	126	100	"	D-0	"	118	145	42
7.30 A.M.	2½	"	"	"	112	115	88	2	B-0	"	101	130	35
Car forward 8.00	"	"	"	"	115	118	90	0	C-0	"	105	135	35
5.30 P.M.	"	"	"	"	125	125	100	"	D-½	"	112	140	40
7.30 A.M.	"	"	"	"	125	125	100	"	B-0	"	112	140	40
	"	"	"	"	125	125	100	"	C-¼	"	120	145	45
5.30 P.M.	0	"	"	"	125	125	100	"	D-½	"	120	145	45
7.30 A.M.	2½	2½	"	"	112	115	88	1½	B-0	"	105	135	35
Car forward 8.00	"	"	"	"	117	120	90	0	C-¼	"	109	140	35
5.30 P.M.	"	"	"	"	120	122	92	"	D-½	"	112	140	40
7.30 A.M.	"	"	"	"	125	125	100	"	B-0	"	120	145	45
	"	"	"	"	127	127	100	"	C-¼	"	115	145	40
5.30 P.M.	0	"	"	"	130	130	100	"	D-½	"	140	145	43
7.30 A.M.	1½	2½	"	"	115	120	85	2	B-0	"	100	128	35
Car forward 8.00	"	"	"	"	120	122	92	0	C-¼	"	105	135	35
5.30 P.M.	"	"	"	"	125	125	100	"	D-½	"	109	140	35
7.30 A.M.	"	"	"	"	125	125	100	"	B-0	"	115	145	40
	"	"	"	"	125	125	100	"	C-¼	"	115	145	40
5.30 P.M.	0	"	"	"	127	130	93	"	D-½	"	120	145	45
7.30 A.M.	2	2½	"	"	117	120	90	1½	B-0	"	115	133	38
Car forward 8.00	"	"	"	"	120	123	92	0	C-¼	"	112	140	40
5.30 P.M.	"	"	"	"	125	125	100	"	D-½	"	112	140	40

CONTINUE AS ABOVE MAKING TEST OCCASIONALLY UNTIL IN HARMONY WITH DRY TEST.

E X P L A N A T O R Y .

0 Represents Valve or Damper Shut Off
C " Cracked Valve
F " Full Open Valve or Damper
¼,½,1,2,3,4, Represents No.of turns valves are open
¼,½,¾,F, " Amount Dampers are Open.

Kiln Record No. 2

Record No. 2, is for 8-4 Oak, showing a complete record of the steaming and drying, progressively, the cars going in and coming out regularly with readings taken at 7:30 A. M. and P. M. and at noon, and the cars advanced every two days so that each car is steamed for four days before going into the drying chamber, where the same record is continued under the head of "Unloading End."

KILN RECORD. G.R. Veneer Works Progress.

Date	Time Car Enters Kiln	Loading End: Spray.	Coil.	Damp Air.	Fresh Air.	Degrees Wet Bulb.	Degrees Dry Bulb.	Percent Humidity.	Unloading End: Spray.	Damp Air.	Fresh Air.	Wet Bulb.	Dry Bulb.	Percent Humidity.
1907														
9/27	A M													
	4.30P M	2	2	0	0	115	120	83	0	¼	¼	120	140	54
9/28	9.30A M	2½	"	"	"	100	110	70	0	"	"	115	140	45
	4.00P M	3	"	"	"	110	120	83	0	"	"	115	135	50
9/29	9.30A M	3	"	"	"	125	130	85	0	"	"	110	134	43
	3.30P M	3	"	"	"	130	135	84	0	"	"	120	145	25
9/30	9=30A M	2	"	"	"	115	120	87	0	"	"	115	150	33
	4.30P M	3	"	"	"	125	130	85	0	"	"	120	155	36
10/1	10.00A M P M	2	"	"	"	115	120	83	0	"	"	115	150	33
10/2	9.00A M P M	2	"			115	120	83	0	"	"	115	150	33
10/4	9.30A M	3	"			130	135	84	0	"	"	125	160	35
	4.30P M	3	"			125	130	85	0	"	"	120	155	35
10/5	10.00A M	2	"			130	135	84	0	"	"	130	165	36
	4.30P M	3	"			125	130	85	0	"	"	125	160	35
10/6	9.30A M	3	"			155	160	87	0	"	"	130	160	42
	3.30P M		"			155	160	87	0	"	"	135	160	42
10/7	9.30A M	3	"			140	145	83	0	"	"	125	165	30
	4.00P M	3	"			155	160	87	0	"	"	125	160	38
10/8	8.30A M	3	"			150	160	75	0	"	½	130	160	42
	4.30P M	3	"			140	145	83	0	"	"	125	160	35
10/9	9.00A M P.M	3	"			130	135	84	0	"	"	125	160	35
10/11	10.00A M	3	"			130	135	84	0	"	"	125	160	35
	4.00P.M	3	"			125	130	85	0	"	"	110	135	43

Above record dried 2" 18 mos. oak and ash in 12 days. Temp. and Hum. running very low as shown by table.

2" Oak	7.4"		66.7 grams	
Bone dry	7.2"	2.77% shrink & evap	58.4"	14.21%
From Kiln	7.25"		57.3"	
Bone dry	7.02"	.7% " " "	54.17	5.6%

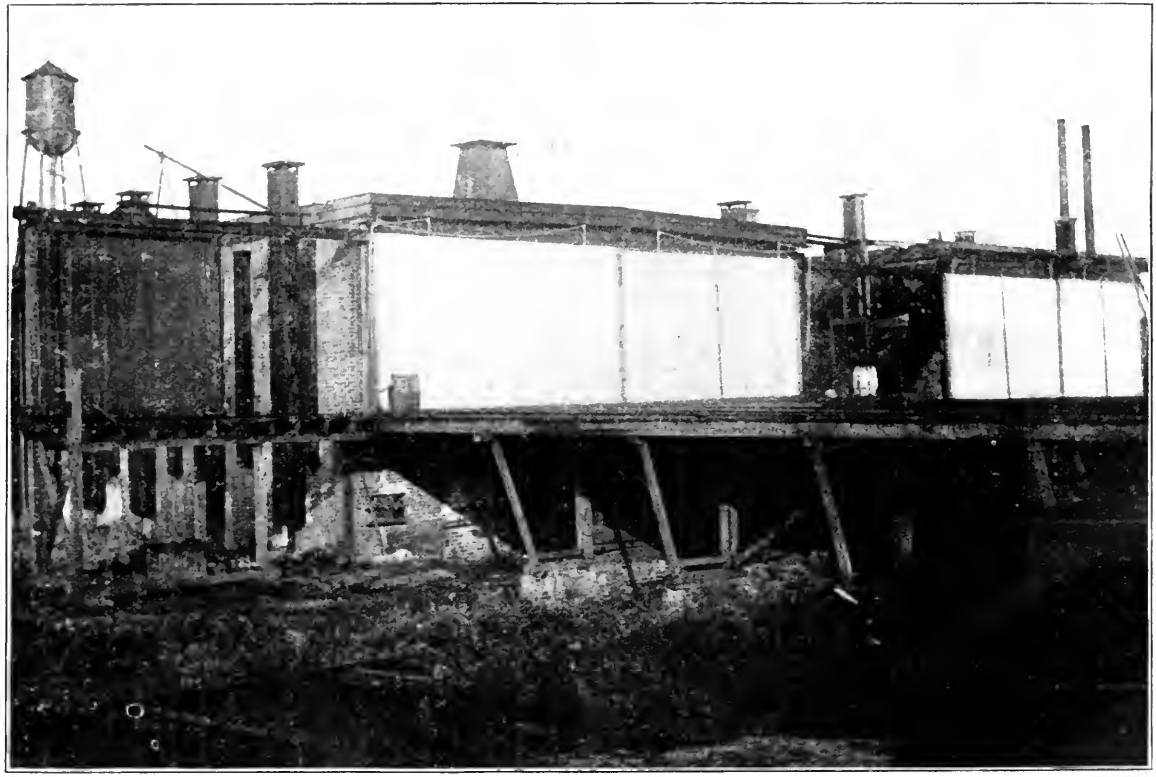
After 2 mos. we measured same piece again, and find on return to normal condition, it stands 1.1 expansion, and absorption has reached 57.3 grams. showing evaportation of lumber when taken from kiln was O.K., but expansion being raised to 1.1 shows lumber was a little too dry when removed from kiln.

Ash	9.9"		97. grams	
Bone dry	9.7"	2% shrink & evap.	88.8 "	9.2%
Dry Ash	9.84"		94.1 "	
Bone Dry	9.75"	9% " " "	89. "	4.8%

This has also been expanded just beyond the 1.2 and absorbed moisture to 94 grams, showing it is as near our table as possible. This we consider most excellent results for time of drying, temperature and humidity carried.

Kiln Record No. 3

Record No. 3 is for 8-4 Oak showing the results when the Dry Test suggestions are followed.



Progressive Kilns

KILN RECORD.

	Date	Hour car enters kiln	END PILING: Car Numbers on Tracks 5 - 6		Thickness	Kind of Lumber.	Date.	Sent Forward.
	Jan							
1	26	4.30	829		1"	Pop	27	7.30
	"	"		830	"	Ches.		11.30
2	27	7.30	834		"	Pop.	28	8.30
	"	11.00		835	"	Ches.		1.30
3	28	8.30		836	"	Mapl.	28	5.00
	"	1.30	837		2"	Pine	29	9.00
	"	5.00		838	"	"		2.00
4	29	9.00	839		1"	Ches.	30	9.00
	"	2.00		840	"	W.A.	2/1	4.30
5	30	9.00	841		"	Mah.	"	"
	"	2.00						
	"	4.30						
6	31	9.00	Sun	day				
	"	4.30						
	Feb							
7	1	9.30						
	"	4.30	843		1"	Ches.	2/1	4.30
	"	"		844	"	"	"	"
8	2	8.30			"			
9	3	10.30	846		"	Pop.	2/4	7.30
	"	"		849	"	"	"	"
10	4	7.30	850		"	Ches.	2/5	9.30
	"	"		851	"	"	"	"
	5	9.30		854	"	Mapl.	2/6	8.30
	"	"	855		1⅓"	Pop	"	"
	"			856	1"	Ches.	2/8	9.00
	6		857		1"	"		
	8	9.00	Sun	day		"		
	"	"		860	1"	Pop.		
		"	861		1"	"		
	9							

When the change of cars is made in the morning, and the kiln is tight enough, the

		Loading End.						Unloading End.				
Date.	Finished.	Spray.	Coil.	Damp Air.	Fresh Air.	Dry Bulb.	% Humidity	Spray.	Damp air.	Fresh Air.	Dry Bulb.	% Humidity.
2/1	1.30	2	F	0	¼	150	100	1	¼	¼	140	55
"	4.30	"	"	"	"	"	"	"		"	150	60
2/3	8.30	"	"	"	"	"	"	"		"	145	55
"	"	"	"	"	"	160	"	"		"	156	60
2/4	8.00	"	"	"	"	150	"	"		"	145	55
"	"	"	"	"	"	140	80			"	140	45
2/5	9.30	"	"	"	"	150	100			"	145	43
"	"	"	"	"	"	"				"	145	40
2/6	10.00	"	"	"	"	140	-			¼	140	45
"		"	"	"	"	160	100			"	140	45
		1	"	"	"	150	"			"	150	40
		0	"	"	"	140	"			"	150	40
		1	"	"	"	140	80			"	150	37
		0	"	"	"	150	80			"	145	40
		0	F	0	¼	140	80	0	¼	¼	158	42
2/8	9.00											
"	"											
		1	F	0	¼	165	100	0	¼	¼	165	40
		F	"	"	"	160	100	2	"	"	"	45
		2	"	"	"	165	100	0	"	"	155	42
		F	"	"	"	"	"	"	"	"	165	40
		0	"	"	"	"	"	"	"	"	160	45
		F	"	"	"	160	100	"	"	"	150	40
		0	"	"	"	100	100	"	"	"	155	40
		0	"	"	"	160	90	"	"	"	160	35
		0	"	"	"	160	100	"	"	"	125	45
		0	"	"	"	100	100	"	"	"	125	45
		0	"	"	"	120		"	"	"	155	35
		0	"	"	"	150	100	"	"	"	185	40
		0	"	"	"	140	80	"	"	"	165	30

spray may be used day time only, the cars being ready to go forward the following morning

Record No. 4 is for mixed lumber, piled lengthwise of the kiln, two tracks side by side, the steaming chamber arranged for one car on each track. This record is still more complete, showing the date of starting, the kind and thickness of lumber and the date of the finishing at the unloading end. The tracks and cars being numbered throughout the battery, it makes it easy to keep the drying record of any desired car.

GRAND RAPIDS VENEER WORK'S PROCESS

PROGRESSIVE KILN RECORD

Kind of Wood ..... WHITE BASS & W MAPLE
Thickness. 4/4
Age ..... 6 MO. & OVER

Address _____

		LOADING END							UNLOADING END					
DATE	TIME TEST IS MADE	SPRAY	COIL	DAMP AIR A	FRESH A.	WET BULB	DRY BULB	PER CENT HUMIDITY	SPRAY	DAMP AIR B.C.D	FRESH A.	WET BULB	DRY BULB	PER CENT HUMIDITY
Aug. 6	A.M.	2	2	¼	F	140	145	85	0	¼	F	130	170	33
		2½		"	"	140	145	82	"	"	"	124	180	33
	P.M.	"	2	"	"	140	145	88	"	"	"	120	180	30
7	A.M.	1½	"	"	"	145	150	75	"	"	"	135	175	33
		"	"	"	"	140	150	75	"	"	"	130	170	33
	P.M.	"	"	"	"	130	140	76	"	"	"	125	166	33
9	A.M.	"	"	"	"	135	145	75	"	"	"	125	165	33
		"	"	"	"	130	145	65	"	"	"	125	170	28
	P.M.	"	"	"	"	130	140	75	"	"	"	120	165	28
10	A.M.	"	"	"	"	135	150	85	"	"	"	130	170	38
		1	"	"	"	135	145	75	"	"	"	125	165	33
	P.M.	1	"	"	"	135	145	75	"	"	"	120	160	30
11	A.M.	1	"	"	"	135	145	75	"	"	"	130	170	33
Rempve	Bass	"	"	"	"	130	140	75	"	"	"	125	165	33
	P.M.	"	"	"	"	130	140	75	"	"	"	125	165	33
12	A.M.	"	"	"	"	130	140	75	"	"	"	120	100	30
		1½	"	"	"	120	125	83	"	"	"	115	150	35
	P.M.	1	"	"	"	120	130	75	"	"	"	120	160	30
13	A.M.	"	"	"	"	130	140	75	"	"	"	120	165	28
Rempve		"	"	"	"	130	140	75	"	"	"	120	165	28
Maple	P.M.	"	"	"	"	128	135	75	"	"	"	115	160	28

EXPLANATORY

0 Represents Shut Valve
C " Cracked Valve
F " Full Open Valve
½,1,2,3,4 " Number of Turns Valves are Open
¼,½,¾,F " Amount Dampers are Open.
Bass to come through in five days.
Maple to come through in seven days.

Kiln Record No. 5

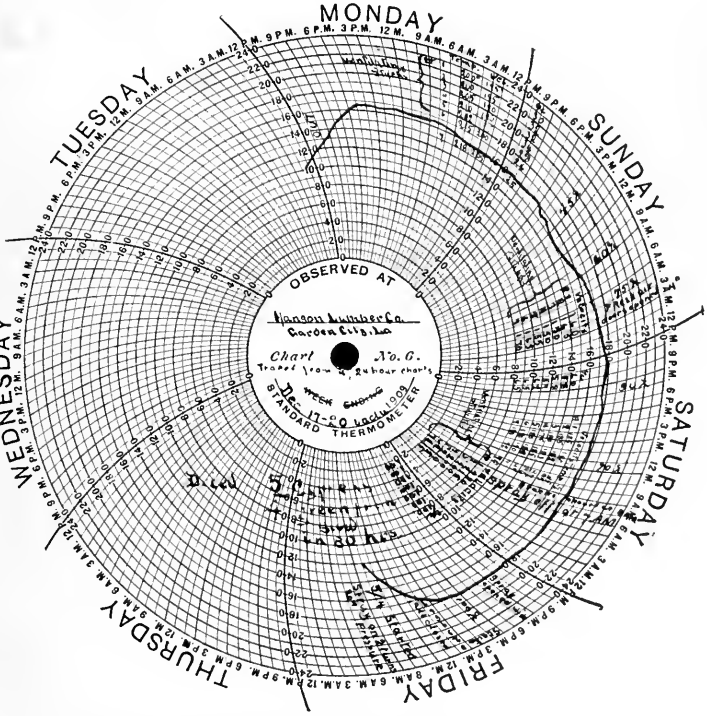
Record No. 5. This record runs low temperature and humidity, while the circulation of air is much in excess of Records Nos. 1, 2, 3 and 4.

The drying of air dried Cypress 2″ thick, by this process, may be accomplished in seven days, with a kiln constructed for drying one year old lumber.

1″ Green Fine direct from the log, may be dried in forty-eight to seventy-two hours.

Green Oak may be dried in ten days, direct from the log.

Hickory squares 16 mos. old, 2″x2″, in seventeen days; 3″x3″, in twenty-three days.



PINE AND CYPRESS—DIRECT FROM THE SAW

These woods are very different in fiber and gums, but are dried under the same general treatment and in the same kilns, by the changing of the steam supply, the temperature, humidity and ventilation.

The time in which one inch Fine and Cypress can be dried varies in proportion to the temperature carried. The higher the temperature is carried, the more rapid becomes the evaporation, and in order to discharge the great volume of water contained in these woods it becomes necessary to increase the proportions of the inlets and outlets, for this class of kilns. For example, in the drying of hardwoods about 12 months old the percentage

of moisture runs between 15% and 35% of their weight, while green soft woods run from 45% to 65% moisture or about two pounds to the square foot for 1" lumber and this volume must be disposed of in one-fourth the time allowed for hardwoods.

A kiln 104' long, 21' 6" wide by 15' high from ground to ceiling, equals 33,540 cu. ft. 14 stacks with 80 square inches of outlet equal 8 square feet, and if a velocity of 500 feet per minute can be produced in these stacks, there will be an exit of 4,000 cubic feet per minute; allowing one-third of the cubic contents to be lumber, this deducted from the 33,540 cubic feet, leaves 23,360 cubic feet; discharging 4,000 cubic feet per minute, this would change the air in the kiln every 5½ minutes.

Again, reversing the proposition, 40,000 feet of 1" pine lumber containing 2 lbs. of water per square foot, or 80,000 lbs., there being 7,000 grains to the lb., gives 560,000,000 grains of water to be evaporated and discharged from the kiln, allowing 57 grains to the cubic foot; discharging 4,000 cubic feet per minute, will discharge 228,000 grains per minute. Dividing 560,000,000 by 228,000 will give 2,456 minutes or 41 hours, to remove the moisture from the kiln, and produce dry lumber.

With these facts in mind it is an easy matter to understand why the heat and circulation must be so intense. When this class of lumber is being dried in a Progressive Kiln, with the vapor system, the valves and dampers are operated practically the same as in the previous instructions for Progressive Kilns and if the Box Kilns are in use the operation is as shown in the Box Kiln instructions, (See Plate VII), but of much greater intensity and shorter duration, finishing the spraying or steaming in about 8 hours. (See Box Kiln Plate VII). Then the steam begins to come from the lumber and is kept under compression for about 6 hours, when the dampers are opened up to full capacity and the moisture is drawn off as rapidly as possible, varying from 48 hours to 96 hours, depending upon the temperature carried and the amount of water in the green lumber. With these general remarks and a careful study of foregoing records and instructions it makes the drying of soft green lumber a very safe proposition.

This kiln chart from recording thermometer, shows the time for drying 1¼" Cypress green from the saw in 80 hours.

To be read the same as the diagram on page 15, beginning at Friday and ending at Monday.

CHAPTER II.

BOX KILN INSTRUCTIONS

1. The drying of lumber by the box kiln process consists of:

   First — Exposing the lumber to the direct action of steam intermingling with the lumber;

   Second — Gradually displacing the steam with dry heat from the heating coil;

   Third — Removing the damp or vitiated air from the bottom of the kiln by a system of ventilation.

2. PLACING THE LUMBER IN THE KILNS. Great care should be taken to see that there is a free space of not less than 6″ between the lumber and the side of the kiln. The spaces between the boards in the lower courses of lumber should be from 6″ to 8″ in width, graduating to 1″ as the pile approaches the top. The last four or five courses at the top should not have more than 1″ between the edges of the boards. Lumber piled in this manner allows for the thorough circulation of the heat and moisture through the pile, and equalizes the heat through the entire load. Arrange Test Gauge Sticks as per our Dry Test Suggestions. (See Chapter 3.)

3. STARTING THE KILN. After placing the lumber in the kiln as described above, close the damp air dampers and doors as tightly as possible. The fresh air dampers should remain partly open all of the time, but not enough to remove pressure from the kiln. Turn on the steam spray three or four turns of the valve, according to the pressure, and leave it from ½ to 3 hrs., in order to fill the kiln with moisture. At the same time turn the steam on in the coil sufficiently strong to blow out the condensation. Then reduce the opening of the coil valve, to keep the coil warm, being careful that the rise of temperature is as gradual as possible. Now, the humidity will soon be brought to 80% or 90% and the temperature to 140 or 150 deg. This temperature can be quickly reached; sometimes in two or four hrs. After this time it will rise more slowly, and may require more heat from the coil and the steam spray, but do not try to force the heat for 48 hrs., at which time the temperature may be 165 or 170 deg. F., but it

should come gradually. At 43 hrs. the temperature should be gradually rising to 170 deg. The amount of spray should now be gradually reduced, and if the temperature and humidity will continue without decreasing, it is apparent that the moisture is coming from the lumber sufficiently to produce the desired humidity. As the temperature increases, the humidity should increase, for the heat causes the moisture to come from the lumber. When the moisture coming from the lumber is 90 to 100 per cent., allow it to remain so for 24 hrs. (See page 55). Then draw the dampers in the stacks one-fourth open. This will remove the air from the bottom of the kiln. Notice the moisture this time, as the hygrodeik will show the moisture gradually disappearing, but the humidity should not be allowed to drop below 60% for the fifth day, while the temperature may be 165 to 170 deg.

5. TIME TO MAKE TEST. On the fourth or fifth day, draw a test piece from the kiln through the opening left for the hygrodeik, and if the shrinkage test shows $\frac{1}{8}$" in 12", it will indicate that in 24 hours or 48 hours the lumber will contain 4% to 5% moisture. (See Dry Test Suggestions, Chapter 3). When this condition of the lumber is reached, shut off the coil, open up the dampers to the stacks and allow the kiln to cool, keeping the steam on the equalizers in the stack, so that the humidity which comes from the lumber may be drawn out of the kiln. It is desirable to keep the lumber on sticks until it is cool, to avoid possible warping or twisting.

6. DRYING THICK STOCK. For drying thicker and greener stock, follow the same process, allowing 2" stock twice the time in the steaming and 3" stock three times the steaming that would be allowed for 1", being careful that the time for raising the temperature is extended in proportion to the thickness of the stock. Fourteen days should be consumed for 2" and twenty-one days for 3" stock for complete drying, keeping the humidity as near 100% as possible, without staining the lumber, during the four or six days of steaming.

The summary of the above for 1" hardwood is as follows: The first 48 hrs. is consumed in getting the moisture to be self-produced by the heat from the spray and the coil, the hygrodeik registering 150 deg. on the dry bulb and not less than 90 or 100% humidity.

The following tables are records kept during the operating of kilns, and should be closely followed. Pick out the table showing the stock to be dried, or

the one nearest to what you want, and proceed on low temperature table first. As the operator becomes familiar with what the valves and dampers do, he will soon be able to run higher temperatures.

Tables No. 1, 2 and 3 show the thickness and kinds of lumber that may be dried by each, (the temperature of the dry bulb being shown with the percentage of humidity). (See Hygrodeik Instructions, Chapters 4 and 5).

Tables No. 4 and 5 show the time required for oak particularly, and the time and amount of the changes which are made with the valves and dampers. They also show dry bulb readings and percentages of humidity, morning and evening of each day.

No. 1. Kiln Record for drying various kinds and thicknesses of lumber. 4-4 Oak, Beech, Maple, African Mahogany, Ash and Hickory. H for Humidity. T for Temperature.

Days	1	2	3	4
	T-H	T-H	T-H	T-H
A. M.	60-50	130-90	130-90	150-80
Noon	120-90	140-90	140-80	160-80
P. M.	120-90	140-90	150-80	160-80
Days	5	6	7	8
	T-H	T-H	T-H	T-H
A. M.	150-80	150-60	150-50	150-40
Noon	160-70	160-60	160-40	150-35
P. M.	160-70	160-50	150-40	150-35

No. 2. Kiln Record 4-4 Gum, Cottonwood, Poplar, Pine and Mexican Mahogany.

Days	1	2	3	4	5
	T-H	T-H	T-H	T-H	T-H
	60-60	130-90	150-80	150-50	150-40
Noon	130-99	140-80	160-70	150-40	150-35
P. M.	120-99	150-80	160-70	160-40	150-35

To dry White Maple and Basswood and keep them white, keep the temperature 10 deg. below and the humidity 20% lower than shown in table No. 2 for the first four days, cool down the 5th day.

No. 3. Kiln Record 8-4 Oak, Birch, Maple, Hickory, Ash, African Mahogany.

Days	1 & 2	3 & 4	4 & 6	7 & 8
	T-H	T-H	T-H	T-H
A. M.	60-60	130-95	130-95	140-80
Noon	120-90	140-95	140-95	150-80
P. M.	120-95	140-95	150-95	160-80
Days	9 & 10	11 & 12		13 & 14
	T-H	T-H		T-H
A. M.	140-80	150-60		150-40
Noon	150-75	150-55		150-35
P. M.	160-70	150-45		145-30

Begin to cool off on the 14th day, and leave the lumber 24 to 48 hrs. on the piling sticks. For 8-4 Bass, Poplar, Cottonwood, Pine, Mahogany, run same way as 4-4 Hardwood, if necessary extend two days.

No. 4. Kiln Record 4-4, 12 month Oak.

	Time Record was Made	Spray	Coil	Damp Air	Fresh Air	Degree Dry Bulb	Per cent Humidity
Steam turned on at 7:00 a. m. First reading taken at 9:00 o' clock.							
A. M.	9.00	4	0	0	0	150	90-100
Let temperature go as high as spray will take it.							
P. M.	5.00	3	0	0	0	190	90
A. M.	8.30	2	0	0	0	185	90
Start to open damp air.							
P. M.	5.00	1	0	½	0	180	90
A. M.	8.00	½	2	½	0	180	90
Start to open coil.							
P. M.	4.30	C	4	½	0	175	90
A. M.	8.30	C	6	½	0	175	85
P. M.	5.00	C	F	½	0	175	90
A. M.	7.30	C	F	F	0	170	70
P. M.	5.30	C	F	F	¼	170	60
Start to open fresh air.							
A. M.	8.30	O	F	F	½	165	50
Shut off spray.							
P. M.	4.30	O	F	F	½	165	40
A. M.	8.30	O	F	F	F	165	30
Damper open.							
P. M.	5.30	O	F	F	F	170	20
A. M.	7.30	O	O	F	F	170	18
P. M.	5.00	O	O	F	F	120	18

1" Maple requires five days for drying, the steam spray being used lightly with 80% humidity for 24 hours; then humidity gradually lowered to 20% in 5 days. 1" Birch takes 6 days, and should be sprayed for 36 hours with 80% humidity.

No. 5 Box Kiln Record. 18 month 2½" Plain Oak. 12 months 2½" Birch. See plate III, test piece 1.

Explanation of Following Table

O represents damper or valve shut off.

C represents cracked valve.

F represents full open.

½, 1, 2, 3, 4, number turns valves are open.

¼, ½, ¾ F. Amt., dampers are opened.

		Hour Record Made	Spray	Coil	Damp Air	Fresh Air	Degree Dry Bulb	Per Cent. Humidity
1	Noon		3	0	0	0	190	90-100
	P. M.	5:30	4	0	0	0	190	90-100
2	A. M.	8:00	4	0	0	0	190	90-100
	P. M.	5:00	4	0	0	0	195	90-100
3	A. M.	7:30	3	0	0	0	195	90-100
	P. M.	5:30	3	0	0	0	195	90-100
4	A. M.	7:30	3	0	0	0	195	90-100
	P. M.	5:30	3	0	0	0	190	90-100
5	P. M.	7:30	2	1	0	0	190	90-100
	P. M.	5:30	1	2	0	0	185	90-100
6	A. M.	7:00	1	2	1/4	0	185	90-100
	P. M.	5:30	1	4	1/4	0	185	90-100
7	A. M.	7:00	1/2	F	1/2	0	180	90-100
	P. M.	5:00	1/4	F	1/2	0	175	90-100
8	A. M.	7:00	C	F	1/2	0	170	90-100
	P. M.	5:00	C	F	1/2	0	170	90-100
9	A. M.	7:00	C	F	1/2	0	170	90-100
	P. M.	5:00	C	F	3/4	0	170	90-100
10	A. M.	7:00	C	F	F	0	170	90-100
	P. M.	5:00	C	F	F	0	165	90-100
11	A. M.	7:00	C	F	F	1/4	170	85
	P. M.	5:00	C	F	F	1/4	170	80
12	A. M.	7:00	C	F	F	1/2	170	75
	P. M.	5:00	O	F	F	1/2	170	70
13	A. M.	7:00	O	F	F	1/2	170	60
	P. M.	5:00	O	F	F	3/4	170	50
14	A. M.	7:00	O	F	F	F	170	40
	P. M.	5:00	O	F	F	F	170	30
15	A. M.	7:00	O	F	F	F	170	20
	P. M.	5:00	O	F	F	F	170	20
16	A. M.	7:00	O	F	F	F	170	19
	P. M.	5:00	O	F	F	F	170	18
17	A. M.	7:00	O	F	F	F	170	18
	P. M.	5:00	O	F	F	F	170	18
18	A. M.	7:00	O	O	F	F	150	18
	P. M.	5:00	O	O	F	F	145	15
19	A. M.	7:00	O	O	F	F	120	25
	P. M.		O					

Let Temperature go as high as it will, due to spray only.

Start to open damp air stack the sixth day.

Spray off 12th day, shut off coil one day before lumber is taken out, let air pass through ventilation to cool off kilns. 2½" Oak should be dry. It may not be possible to obtain these exact conditions of temperature and humidity, but they are the ones to be tried for. 2½" Beech requires 13 days, and is sprayed strongly three days and then gradually reduced.

MISCELLANEOUS INSTRUCTIONS FOR OPERATING KILNS

Fresh Air.

1. Under what conditions should fresh air dampers be opened? Closed?

   Ans. The kiln will not take in cold air through the flues until the lumber ceases to produce all the moisture that the stack can carry away. When the inlet is lower than the tracks, they can always be open.

   WET END. The cold air will go in as long as the spray is being condensed and stops when the lumber becomes moist and hot, producing a comparison.

   DRY END. When the lumber is not producing moisture at the dry end then the cold air will flow in and increase the moisture.

2. What results will be obtained if open?

   Ans. The kiln will only draw the amount of air necessary to carry off the moisture when lumber is dry, but worked as a Pressure Kiln, it is fairly balanced.

DAMP AIR

3. Under what conditions should damp air dampers be opened or closed?

   OPENED. Sufficient to draw off humidity without reducing the temperature.

   CLOSED. Close for holding the heat to dry, during the night, without steam.

4. When should stacks be smothered?

   Ans. When it is noticed that the lumber is not producing sufficient moisture to make the necessary pressure in the kiln to force the humidity between the boards, as they are piled on the cars.

5. What should be done if Temperature is high and Humidity high at the dry end of the kilns?

   Ans. Open up the dampers on all the stacks

7. What should be done if Temperature is high and Humidity low in sweating chamber?

   Ans. Smother the stacks or turn on spray.

8. What should be done if lumber is case hardened?

   Ans. If severely case hardened, unload and steam and dry again, but if slightly so, and there is sufficient time to allow it, raise the humidity to 80% or 90% in the dry end, over night, and allow the kiln to dry down to normal before removing lumber.

9. How should green lumber be handled from the mill?

   Ans. Same as dry lumber, a small amount of spray being necessary. The required humidity is easily raised—the dampers in the steaming chamber could be ½ opened in about 14 hours, or after standing over night with a good compression.

10. How should the kiln be adjusted to stand idle or at rest for several days?

   Ans. Smother half the stacks, turn off the steam and let it all die down together.

CHAPTER III.

DRY LUMBER TEST SUGGESTIONS

The manufacturing and handling of lumber for the different uses to which it is designed, bring us into a very wide field and through many variable conditions.

Woods of different shapes and thicknesses are very differently affected by the same treatment. In the case of our native woods, for instance, summer cut lumber and winter cut lumber show distinct tendencies in drying, and the same is true in less degree of heart wood as contrasted with sap wood. The medullary rays further complicate the drying problem and the promiscuous use and combination, in glued up stock, of all these variable conditions require the close attention of the manufacturer and the operator. This variation of hard and soft stock, even in the same quality of lumber compels each establishment to become a law unto itself, and we can offer only our suggestions for a general harmony in the matter of lumber test, by measure and weight.

Plain oak, quartered oak and mahogany require different treatments when properly handled, but in the average drying process these different kinds of wood are all placed in the same kiln and practically treated alike. Hence the difficulty in knowing just when the stock is ready for use. Therefore, we offer the following system for making proper test of shrinkage and evaporation by weight, that each manufacturer may use in his particular business, to adjust the shrinkage to the requirements of his own manufacture, and to specify what is meant by the following terms: Shipping Dry, Factory Dry, Bone Dry and Dust Dry. By the following method of testing a very positive percentage of shrinkage and evaporation may be easily ascertained by the use of the "Gauge Test."

METHOD OF OBTAINING TEST PIECES. In each and every car there should be placed one or two boards in such a manner that they can be removed at any time, so that a test piece can be cut therefrom. Procedure for obtaining this test piece is as follows: Remove a board from the car and cut a piece 1′ long from the center, (thereby getting away from the effects of drying at the end). From this piece cut a strip $\frac{3}{8}$″, full width of the board. This will be known as the test piece. This should be carefully measured

and weighed as follows: Draw a straight line across the face at the middle of this piece. This insures measurements being taken at the same place at all times. A rule divided into tenths should be used as we want to get the measurements to decimals to simplify when reducing to percentages. (See page 69). Each tenth should be divided into tenths. Hence if we had a test piece that measured 6½″ and one-half of the next tenth space it would be written thus: 6.55, above the line at the left hand end of the piece, and the weight in grams, above the line 2″ from the right hand end. After measuring and weighing carefully, place the test piece in a temperature of 200 deg. (the best method of obtaining this is to place the test piece on an iron plate laid on the top of the engine cylinder or hot caul box), leaving it at this temperature for 30 minutes or more to bring to bone dry, which is the base from which we work out our percentages. Now again measure and weigh, and place results under previous figures and you will see that there has been both shrinkage and evaporation. By subtracting and dividing the remainder by the subtrahend you will get the percentage of shrinkage and moisture, above bone dry, which is equivalent to the amount of moisture in the lumber at the time the test was taken. (See page 34).

SHIPPING DRY. To determine when lumber is shipping dry, obtain a test piece, but do not weigh or measure. Bring it to bone dry and then replace the test piece on the board from which it was cut. If there has been a shrinkage equivalent to ¼″ to ⅜″ in 12″ it is safe to call this shipping dry, when it is understood that the shrinkage of most of our native woods green from the log, runs from ¾″ to 1¼″ in 12″.

FACTORY DRY. Procure test piece and reduce results to percentage. For the average factory the shrinkage will be about ¾ of 1% to 1.25% and the evaporation from 3 to 5%. To prove this and find the prevailing conditions of lumber in your factory, make tests from each floor and department, and you will soon know the condition i. e. (the amount of shrinkage and evaporation) the lumber should show when coming from the kiln, to be factory dry. So far as we have been able to learn, the previous percentages are as near general instructions as can be given, but your own factory department tests must establish prevailing conditions at your plant, as these conditions will vary, greatly, with woods and locations. We would advise that you bring the lumber from the kiln slightly drier than the percentages established by your factory tests so that it will absorb moisture from the air during the progress of manufacture, thereby bringing your lumber to a normal condition without straining or warping.

BONE DRY is generally understood to be stock dried down to no shrinkage, and no evaporation, and should be dead piled in dry storage for at least ten days before using and if it is to be left in this storage for any length of time, say more than three months, your storage must be free from excessive moisture. When ready to use this stock, tests should be made from top, middle and bottom of the pile until you know how thoroughly the dry storage is doing its work. These tests might show that the bottom of the pile was carrying from 6% to 10% of moisture and this would necessitate a warming up in hot storage before the lumber was machined beyond the cut-off saw.

ABSOLUTELY DRY OR DUST DRY is stock that has been subjected to an extension of time and intensity of heat. This test is made by taking a 1 ft. block cut from the test board, but cut in the center, lengthwise of the grain instead of cross-wise as before. After a few strokes of a plane to remove the marks of the saw, the next few strokes choke the shavings in the mouth of the plane until a handful is produced. If when these shavings are rubbed together in the hand they do not wad up, but turn to chips and dust, the stock is considered absolutely dry or dust dry and must be dead piled before using.

As a summary of this general description, we offer the following memorandum, using 1" oak direct from the kiln to convey the idea of the proportion of drying and the classification of the different kinds of drying and what it is that produces the distinctive types.

Time in Kiln — Shrinkage Shown by Test Piece

Shipping dry, 4 to 6 days; 1/4" to 3/8" in 12".

Factory dry, 6 to 8 days; 1/8" in 12" ready to use.

Bone dry, 8 to 10 days; no shrinkage, return to storage until 1/8" in 12" can be obtained.

Dust test, 10 to 14 days; no shrinkage, goes to storage to become normal in atmosphere, to obtain 1/8" in 12" expansion.

The following is a memoranda of two tests which were made to prove the changes due to atmospheric conditions. The first test was made on 1" pine green from the log.

Green width . . .	11.2"	Green weight in grams	80
Bone dry	10.35"	Bone dry weight "	46.2
	.85 = 8.21%	"	33.8=73% Evaporation

Six months later (this piece having remained in the normal factory atmosphere of 60% humidity and a temperature of 75 deg.) we find an expansion and evaporation as follows:

Normal Width . .	10.50	Absorption in grams	50
Bone Dry	10.35	Bone Dry "	46.2
	.15 = 1% Expansion		3.8 = 8.4%

The second test was made from a piece of 2" basswood which was never in a dry kiln, but had been in a building over 50 years. This was tested, as above, when removed from the building, with the following results:

Width	6.15"	Weight in grams .	41.7
Bone Dry Width . .	5.05"	Bone dry "	39
	1.10" = 1.6%		2.7 = 7%

Showing that there must be in the neighborhood of 1% shrinkage and from 5% to 8% evaporation above the bone dry test in the lumber when coming from the kiln to be at rest in the normal atmospheric conditions in the factory.

The following tests were made from samples gathered from a wide range of territory, dried by different processes and types of kilns. We do not know the exact number of days required to dry or the time since they were dried, but we offer these as samples of what we find in the different factories and processes of manufacture. No. 1 is O. K., No. 2 shows case hardening by the excess of evaporation over the percentage of shrinkage, No. 3 shows that the evaporation is O. K., but to get the proper shrinkage, this should have remained in the kiln at least 24 hours more.

No. 1	1" Oak	4.65" = 2.1 %	Evaporation	14.2 = 9.2%	as used as interior finish.
		4.55"		13.2	
No. 2	1" Oak	6.43" = 1.2 %	Evaporation	23 = 9.5%	as used as interior finish.
		6.34" = Bone dry		21	
No. 3	1" Oak	8.1 " = 3.26%	Evaporation	31 = 8. %	
		7.85"		28.7	
No. 4	1" Oak	9.75" = .72%	Slightly case hardened	36.5 = 5. %	furniture or cabinet work.
		9.68"		34.5	
No. 5	1" Oak	6.63" = .75%	Too dry for immediate use, should remain in dry storage, shrinkage to scant.	39 = 2.63%	
		6.68"		38	
No. 6	1" Oak	5.85" = 2.27%	Shrinkage dry down nearly 1%	24 = 4.3 %	
		5.72"		23	
No. 7	1" Oak	12.8 " = 1.1 %	all right	62 = 3.33%	
		12.65"		60	
No. 8	1" Pop.	7.18" = .7 %	This will expand 1%	27 = 6. %	Clock Work
		9.98"		25.5	
No. 9	2" W. wood	7.18" = 1.4 %	O. K.	43 = 6.1 %	
		7.08"		40.5	
No. 10	2" W. Ash	7.72" = 1.3 %	O. K.	50.08 = 4.3%	
		7.62"		48	

The following shrinkage and evaporation percentages were obtained from test pieces taken from the cars at the unloading end of the kiln, and being in harmony with the conditions of their process of manufacture are accepted as dry stock and go direct to the machine room. The 3¼" bass resawed into thin lumber without warping, also the 2" elm, which we consider proof sufficient to accept it as the normal condition of the factory.

3¼" bass	shrinkage .76%	:	evaporation 4 %
2" elm	shrinkage 1.47%	;	evaporation 5.5%
1½" bass	shrinkage .86%	;	evaporation 3.2%
1½" bass	shrinkage .60%	;	evaporation 3 %
1½" sugar pine	shrinkage .90%	;	evaporation 5 %
1½" maple	shrinkage 1.10%	;	evaporation 5 %
1½" maple	shrinkage .95%	;	evaporation 5 %
1½" maple	shrinkage .95%	;	evaporation 4.5%

Memoranda showing expansion and absorption in 24 hours by measure and weight of the test piece.

TESTS

Birch 10 days in kiln	10.35" = .97%		31.75g. = .3%	Evaporation
	10.25"		30.8	
24 hours later	10.4 "		32.	
Birch 10 days in kiln	5.3 " = 1.9 %		21.9 g. = 4.2%	
	5.2 "		21.	
24 hours later	5.3 "		22.	
P. Oak 8 days in kiln	8. " = 1.27%	Shrinkage	19.4 g. = 4.8%	
	7.9 "		18.5 g.	
24 hours later	8. "		19.6 g.	

That a uniform method for figuring the percentage of shrinkage and evaporation may be established, the following examples are worked out in full, No. 1 showing the width of the board and the shrinkage to bone dry; No. 2 showing the weight in grams and weight of evaporation.

No. 1, from dry kiln 1" oak.
1" Oak, 7.98" wide
Bone Dry 7.88", subtrahend.

```
7.88).100000(.0126
     788
     ----
     2120
     1576
     ----
     5440
     4728
     ----
      712
```

This answer being in decimals it must now be divided by 100 to make the reading as a percentage Thus, .0126 divided by 100 equals 1.26% shrinkage. Use the same method in testing expansion, using the bone dry dimensions as the subtrahend.

No. 2, the above piece of 1″ oak.
Weighed 45.5 grams.
Bone Dry 43.5 grams.

```
43.5)2.00000(.0459   Read as 4.59%
   1 740
   ----
    2600
    2175
    ----
    4250
    3915
    ----
     235
```

For ease of figuring the remainder would be added and read 1.27% shrinkage, and 4.6% evaporation.

REPORT ON SAMPLES

Gentlemen:

We are in receipt of yours of the 5th, also the samples of the lumber you have dried. We have made tests of the samples with the following results:

2″ Mahogany 6.26″	Evaporation 36.0 grs.	
Bone Dry 6.25 = .16%	35.0	=2.25%
2″ Qr. Oak 4.85″	Evaporation 39.2 grs.	
Bone Dry 4.82 = .6 %	37.9	=3.5 %
1″ Qr. Oak 5.80″	Evaporation 18.0 grs.	
Bone Dry 6.85 = .7 %	17.3	=4. %

Test shows the samples are too dry for immediate use.

We are returning to you under separate cover, pieces of the samples with the figures placed on them so that you can see our method of testing lumber by measure and weight. The usual percentage allowed is 1.25% shrinkage and 4% to 6% evaporation. In other words if you dry a board to bone dry and then allow it to stand in normal atmosphere for a time it will expand 1.25% of its width and absorb from 4% to 6% of its weight, moisture from the air.

The quick way to test lumber is by the sliver test. Take a board that you wish to test and cut it off near the center and then cut a piece off of the fresh cut end, say 3″ long. From this 3″ piece cut a piece cross grain about 1/8″ length of grain. Place this on the steam chest of the the engine or hot steam pipe and let it remain about 20 or 30 minutes. After this time, place the sliver on the piece that it came off of. If this does not show any shrinkage the lumber is bone dry. Now let the two pieces remain in the normal atmosphere for 24 hours and then replace the sliver on the 3″ piece and note how much wider the sliver is than the block. This will show

you where the board will be when it has absorbed the normal atmosphere. Should the sliver after a few hours fail to come back to the width of the 3″ block, the difference between them will show just how much the board lacks of being dry.

You will note that the samples all show that they were below normal when received and were drier when they came from the kiln, showing the necessity of allowing the lumber to stand a considerable length of time before being "worked" in order to avoid trouble with your glue joints. We speak of this for the reason that it is possible to have the lumber too dry when working so that the ends of the lumber will absorb moisture faster than the center, causing them to expand and split either the joint or the lumber itself. It is our desire to gather information from all quarters and so far our experience is, that there is as much, if not more, trouble from over drying than there is from not having the lumber dry enough. We will be pleased to receive samples from you at any time as it is our desire to keep in touch with our patrons so as to be able to render any and all the assistance possible. Thanking you we are,

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GAUGE TEST

of samples of $1\frac{1}{4}$" Plain sawed Birch, 12 months stock.

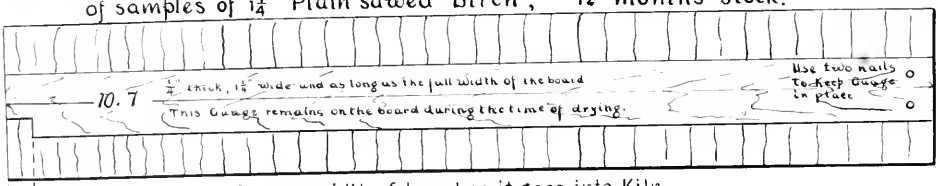
10.7
$\frac{1}{4}$" thick, $1\frac{1}{2}$" wide and as long as the full width of the board
This Gauge remains on the board during the time of drying.
Use two nails to keep Gauge in place

FIG. 1. Green width of board as it goes into Kiln

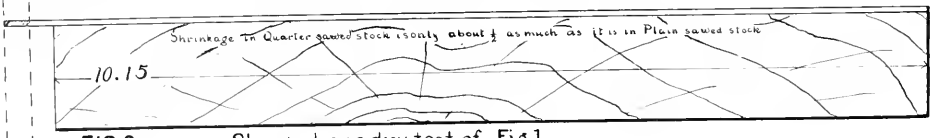

FIG. 2. Shows bone dry test of Fig. 1.

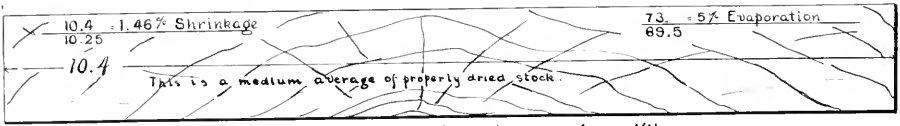

FIG. 3. Shows width of board as it comes from Kiln

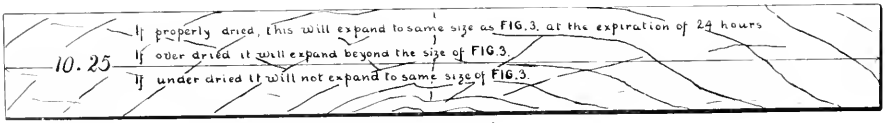
If properly dried, this will expand to same size as FIG. 3. at the expiration of 24 hours
10.25
If over dried it will expand beyond the size of FIG. 3.
If under dried it will not expand to same size of FIG. 3

FIG. 4. Shows bone dry test of Fig. 3.

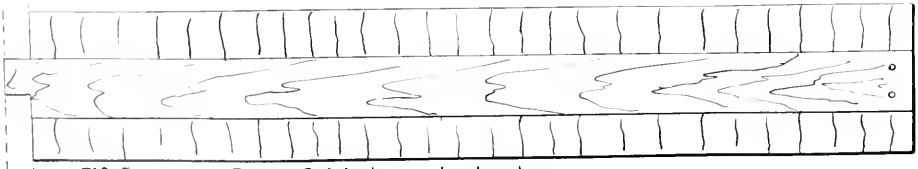

FIG. 5. Gauge Stick shows dry lumber.
Evaporation test should now be made

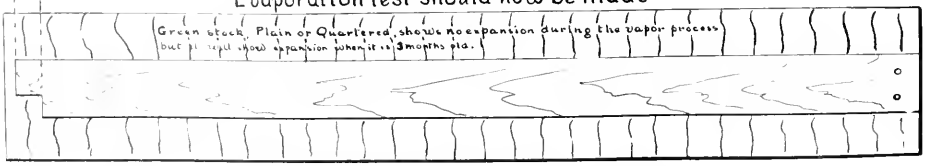
Green stock, Plain or Quartered, shows no expansion during the vapor process
but it will show expansion when it is 3 months old.

FIG. 6. Gauge Stick shows expansion of lumber during vapor process period.

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GAUGE TEST

of samples of 1" Plain sawed white Oak, 12 mo. stock

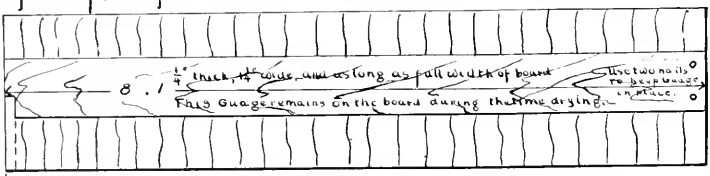
8.1
1/4" thick, 1" wide, and as long as full width of board
This Gauge remains on the board during the time drying
Effective nail to be kept under in place.

FIG. 1. Green width of board as it goes into Kiln.

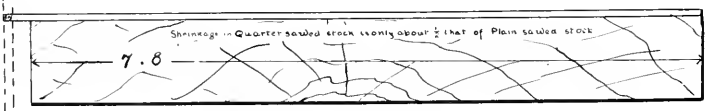

FIG. 2. Shows bone dry test of Fig. 1.

FIG. 3. Shows width of board as it comes from Kiln.

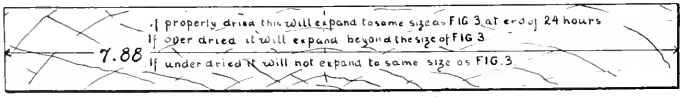
If properly dried this will expand to same size as FIG 3 at end of 24 hours
If over dried it will expand beyond the size of FIG 3
7.88
If under dried it will not expand to same size as FIG. 3

FIG. 4. Shows bone dry test of Fig 3

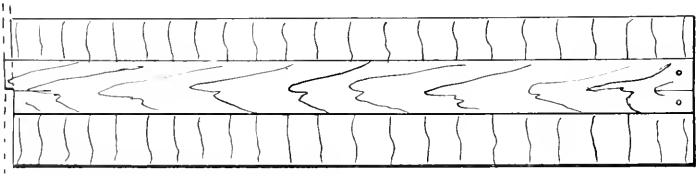

FIG. 5. Gauge Stick shows dry lumber.
Evaporation test should now be made.

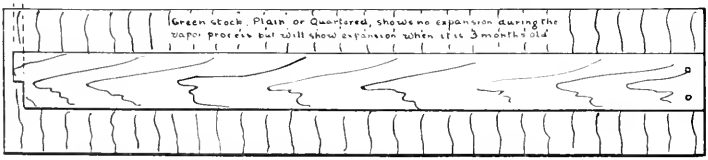
Green stock, Plain or Quartered, shows no expansion during the vapor process but will show expansion when it is 3 months old

FIG. 6. Gauge Stick shows expansion of lumber during vapor process period.

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THE DRY TEST GAUGE.

See Plates I and II.

This is a gauge (Fig. 1) that enables one to predetermine the shrinkage of the lumber and to know when it is dry. Also, with gauge stick applied, the different changes of the lumber during the process can be noted.

To avoid confusion in making test pieces, it is fitting here to call attention to the fact that it is necessary for each firm to make several tests, and establish a percentage for their own requirements and location.

It is only possible for us to offer suggestions along this line, that a uniform method of testing may be established. While percentages will be variable according to location, percentages will also vary with different kinds of lumber and the thoroughness with which the lumber has been steamed. If the steaming was insufficient to remove the acids, then the test piece will show very nearly the same percentage as the green test piece from the yard, which was dried in the caul box or on the hot plate.

This piece does not go through the process of elimination, as in the Vapor process. It still contains the acids, and when dried down to bone dry will show a greater percentage of shrinkage than the test piece taken from the same board after having been dried by the Vapor process.

To predetermine the distance from the end of the GAUGE STICK to the proper place for cutting the shoulder for shrinkage, use the Bone Dry test piece cut from the lumber before it enters the kiln, using 1″ lumber as standard. Then add to each different width the following amount:

6″ wide lumber, add 1/16″ to the bone dry test.

8″ wide lumber, add 1/8″ to the bone dry test.

10″ wide lumber, add five-thirty-seconds of an inch to the bone dry test.

12″ wide lumber, add two-tenths of an inch to the bone dry test.

Gauge test plate No. 1, Fig. 1, shows gauge stick applied to board as it comes from the yard, and Fig. 2 shows the shrinkage when removed from the hot caul box and brought down to bone dry.

Fig. 6 shows expansion beyond gauge stick during the Vapor process period. Now this expansion is necessary on stock from the yard in order to soften up the lumber on the outside so that it may dry thoroughly through and through.

It is a well known fact that the dryer the lumber is

the greater the tendency to drink in the humidity of the atmosphere. The fact has been established by many and varied tests that 1.25% shrinkage above bone dry is a very safe percentage for drying lumber. The evaporation in the steam process and the shrinkage in the drying process can be readily noted from the start to the finish.

As soon as the test gauge shows shrinkages down to the notch, a test from the board should be made.

Fig. 3 shows the test piece as taken from board after it has gone through the dry kiln and shows that the lumber has shrunk from 10 7-10" down to 10 4-10".

Now the piece shown in Fig. 3 when being tested in hot caul box is brought down to bone dry as shown in Fig. 4. Fig. 4 shows 10.25" making a 1.46" shrinkage and an evaporation of 5%. This is about the average that the lumber would show coming from the kiln, to produce stock that would remain at rest in Grand Rapids, Mich.

Fig. 5 gauge stick shows shrinkage of the lumber down to the notch or as shown in Fig. 3 and ready to be removed from the kiln. This is not always uniform with the evaporation and may require another 24 hours to reach the four or five per cent evaporation. Should the operator find that his factory test of stock in process of manufacture requires a greater or less percentage of shrinkage and evaporation, he should make the gauge stick to correspond, but in all cases use the bone dry figures for the base of expansion and evaporation.

As further proof that tests should be made to find the condition the lumber should be in at your factory to come to normal condition and to be at rest, we show Plates III and IV, cuts of samples.

No. 1 shows 2½" white oak stock dried in 18 days. This stock shows less than 1% shrinkage and 4.4% evaporation, and being plain oak sawed, it holds its full size and does not indicate case hardening.

No. 2 represents 2" plain sawed oak and shows excessive hardening, but is not honey-combed. It is thoroughtly browned inside from the action of the retained acid.

No. 3 represents quarter sawed oak and is a fine specimen of drying.

No. 4 represents the end of the same board and matches No. 3 on these exposed faces, and would show exactly the same size, but No. 4 has never been in the dry kiln and was ¼" larger than No. 3 when No. 3 was removed from the kiln. After three years' exposure to the atmosphere in an office, No. 4 is much narrower than No. 3, and also thinner. Now it appears that the acids re-

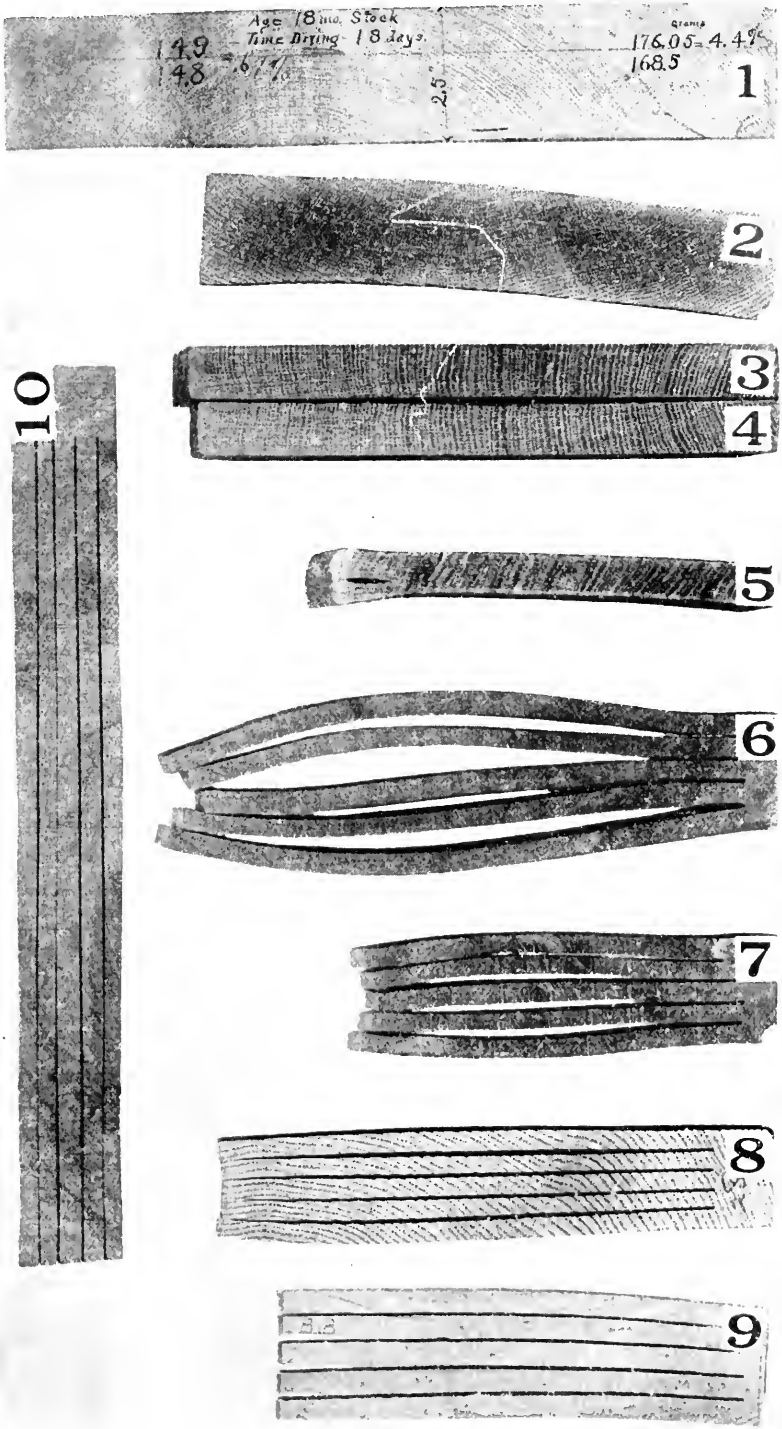

Age 18 mo. Stock
Time Drying 18 days
14.9
14.8
2.5"
Grams
176.05 - 4.47
168.5
1
2
3
4
5
6
7
8
9
10

Plate III

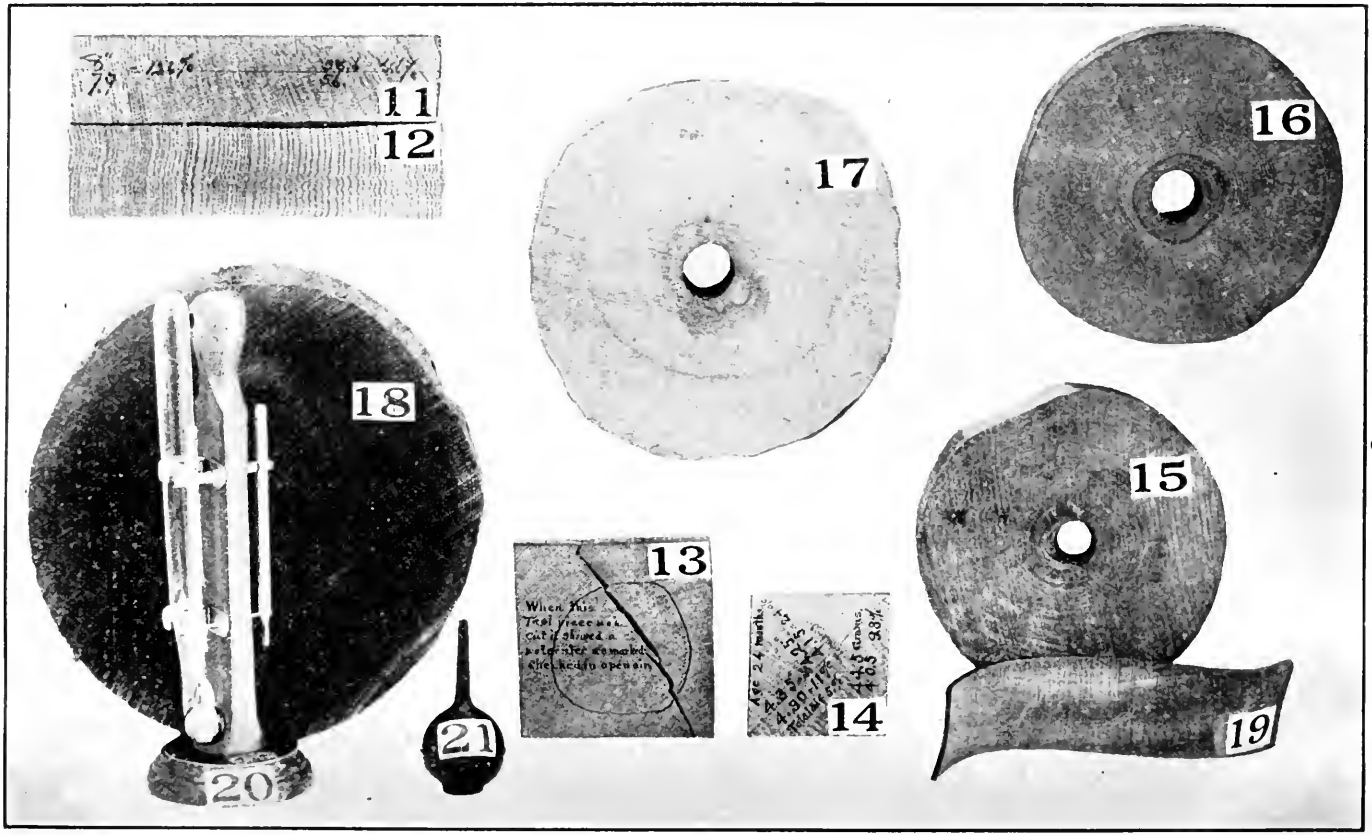

11
12
17
16
18
13
When this
Test piece was
cut it showed a
micrometer scratch
checked up on
15
14
Age 24 months
19
21
20

Plate IV

maining in the air dried lumber, such as in No. 4, still continue to consume the fiber, shrinking it down smaller and smaller as time passes, proving that these acids should be removed from the lumber during the drying process. This, it will be noticed, is working in harmony with the difference in the shrinkage between our previous test of lumber directly from the yard to the hot plate and the test from the Vapor process lumber when dried on the hot plate. (See Fig. 2, page 39).

No. 5 represents another extreme of drying lumber without humidity, and shows one-inch quarter sawed oak shrunk down to ¾″ thick, and very hard to manufacture.

No. 6 representing a test of 2″ gum and shows that the outside was case hardened while the center was only half dry. This lumber would not have shrunk to the size of the center piece, no matter how long it was in the kiln under the old process, without steam saturation.

No. 7 represents a test piece nearly dry, but still showing case hardening, the center shrunk down below the outside.

No. 8 represents a test on 2″ oak. This is in good condition.

No. 9 represents 2″ elm. While the whole plank was slightly cupped, the stock was beautifully dried by the steam process through and through, without case hardening.

No. 10 represents 2″ gum still better dried so that it would split up into thin pieces without warping. These tests will show very clearly why the evaporation tests should be made, and when the operator becomes familiar with his kiln and his lumber, these sample tests will convey the idea of good and bad drying to such an extent that it will not be necessary, in ordinary drying, to make the same dry test on every car load of similar stock following.

No. 11 represents a piece of 2″ quarter sawed oak, showing 1.26% shrinkage and 4.6% evaporation, without the slightest sign of case hardening.

No. 12 represents a 2¼″ piece of quartered oak dried by the old process that shrunk down to 1⅞″, and is case hardened.

No. 13 represents a test piece from 4¼″ squares of oak, and when this piece was exposed to the atmosphere it showed a wet center, as indicated by the black line. When exposed to the atmosphere a check was made as shown in the cut. This proves that honey-combing in lumber is produced by the outside being case hardened to such an extent that construction in the center can not pull the sides together as shown in No. 5. This also is proved by the thick end of No. 5.

No. 14 represents a test piece from the 3″ square oak, with a heart in the corner, making it quarter sawed on the line 4.35″ and plain sawed on the line 4.25″. It will be noticed that the extreme difference between 4.35 and 4.15 which is bone dry test, is 5%, showing the reason why it is so difficult to dry squares and have them remain square. The quarter sawed shrinks less than ½ the plain sawed. This proves another fact, that in making gauge sticks for quarter sawed lumber the allowance will be one-half the amount shown on plates Nos. 1 and 2 on gauge test.

No. 15 represents a cutting from green elm block, 8″ in diameter, cut direct from the log and dried by vapor.

No. 16 represents a cutting from green beech block, 8″ in diameter, cut direct from the log and dried as No. 15.

No. 17 represents a cutting from green maple block, 9″ in diameter, cut direct from the log and dried as 15-16.

No. 18 represents a cutting from green white oak block 10″ in diameter, cut direct from the log and dried as 15, 16, 17.

No. 19 shows a cross cut piece, ⅛″ length of grain, cut from No. 6 before it was ripped. This curls into the form of the letter "S," showing the disposition of gum lumber to get off from the straight line.

No. 20 shows the Humidograph as used while taking a reading for the percentage of humidity in the kiln.

No. 21 shows a rubber bottle which is used for filling the tall glass bottle which furnishes the water for cooling the wet bulb. See Humidograph, on page 56.

SHOE LAST BLOCKS AND HUB BLOCKS.

Among the articles manufactured from wood, the shoe last and the wagon hub rank as the most difficult to air dry in storage sheds. Therefore there must be some artificial means of drying the blocks suitable for manufacturing into the finished articles. The principal difficulty in drying hubs is the tendency for the ends and sides to check, on account of the great amount of surface on the outside, or circumference of the block, as compared with the center. This is relieved somewhat by the customary practice of boring a hole in the center, but even then the blocks check very badly in the open air. Now the shoe last block is taken from the log around and free from the center of the log and split into size suitable for the ease of last desired. After being roughened out to form this block, then it becomes a problem in drying, as it then has a large heavy center, while either end is much smaller.

The problem now is to keep the small ends from checking because of over drying, and the middle from checking on the outside while the inside is still damp and moist. These difficulties have been overcome and the time of drying greatly reduced, as shown by the Kiln Record.

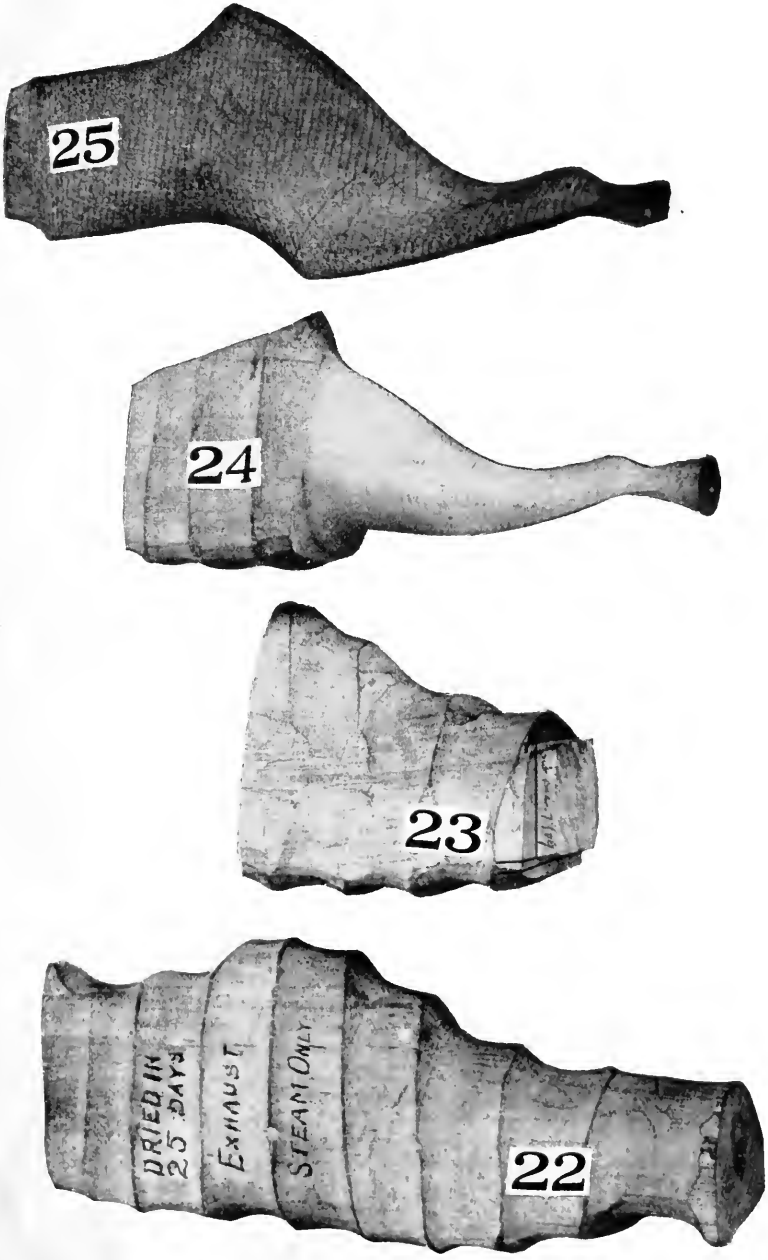


Plate V

Photographs of different stages of finish, also the method of testing for shrinkage and evaporation is shown by the following cuts:

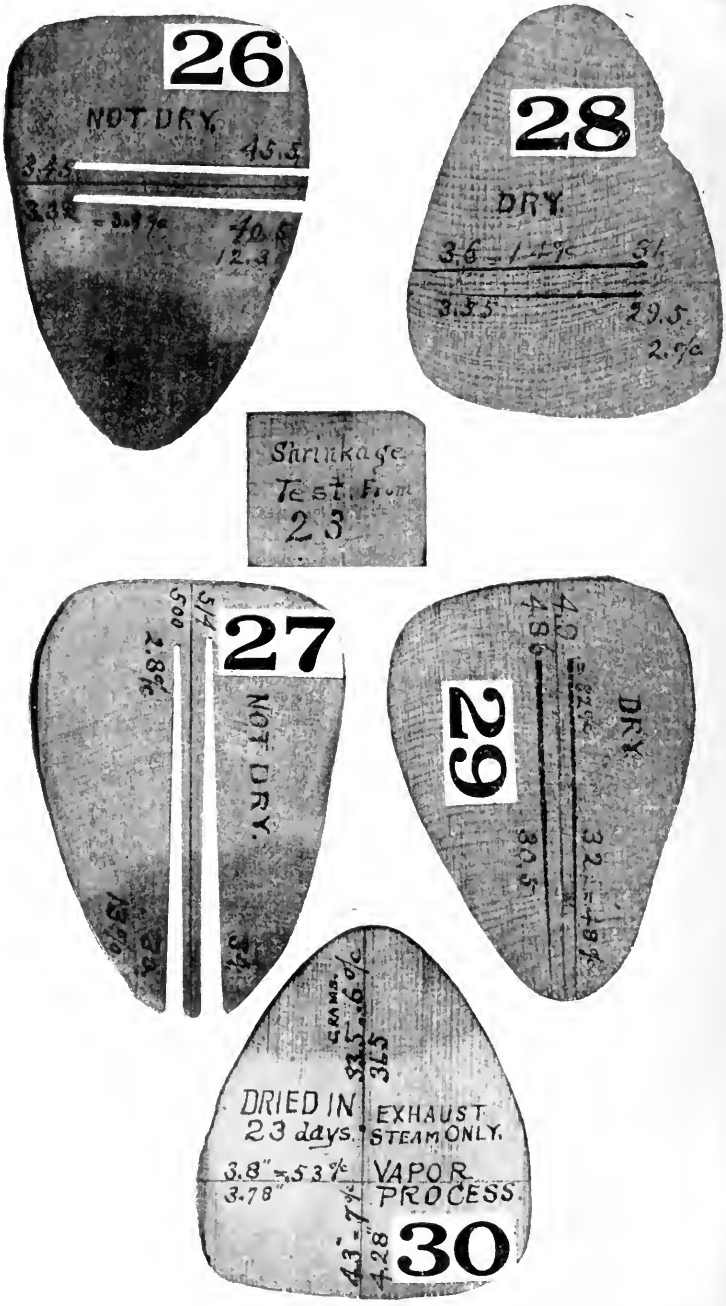
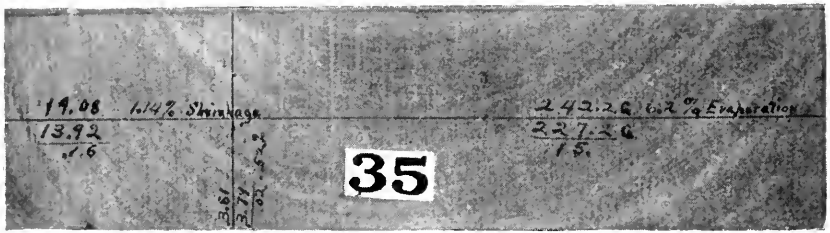
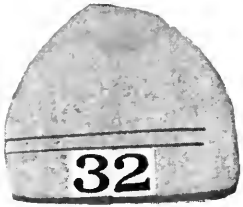


Plate VI

38


19.08
1.14% Shrinkage
13.92
1.6
242.26
6.2% Evaporation
227.26
15
35

31


32

33

34

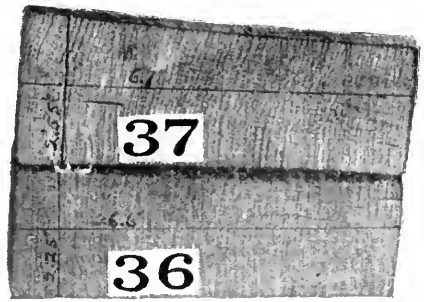

6.7
37
6.6
36

Plate VII

No. 22 represents a block that was dried in 23 days.

No. 23 represents a square end formed on the toe with a piece cut therefrom 1/4" length of grain. This is thoroughly dried on a hot plate to test the shrinkage.

No. 24 represents a block partly shaped to the finished form.

No. 25 represents a last fully formed as it comes from the lathe.

No. 26 represents a section cut from the center of a rough block. As a test piece notice that it is not dry. See percentages, and form of the openings.

No. 2 7represents a section from the same block, but is on the quarter cut of the log.

No. 28 represents stock that has been overdried. Notice the percentages of contraction.

No. 29 represents stock that has been overdried. Notice the percentages.

No. 30 represents still another dry section, showing percentages. When these percentages are established as correct for each different factory, then it is possible to weigh rough block before going into the kiln, and it should be placed where it can be removed at the time for testing. Weigh and deduct from first weight and in this manner the percentage of moisture remaining in the block is readily determined. Thus it is possible at all stages of the drying process to know just the amount of moisture that has gone into the block during the steaming and what percentage still remains above the desired percentage which has been previously ascertained by the Section Tests of Measure and Weight. The exact condition of the blocks can then be obtained by weight and measurement after exposure in the kiln, and reference to the examples given on pages 36-37.

Nos. 31 and 32 show section from a last, 1" thick, with the 1/4" tongue. There is no preceptable variation in the length.

Nos. 33 and 34 are from the same block, sections of the tongue cut 1/4" thick, these also show no change.

No. 31 and 34 are sawed on the quarter, while Nos. 32 and 33 are sawed plain, the two showing no difference in shrinkage after being aclimated to the atmospheric conditions.

No. 35 shows a piece of 4 x 14 mahogany.

No. 36 shows a piece of 8-4 quarter oak as was taken from the yard.

No. 37 shows a piece of the same plank after drying. Note the dimensions.

No. 38 shows a piece of "glued up" top, which was, at the time of gluing, the same width as the moulding on end is long.

No. 39 shows the effect of air drying on round timber, compare with Plate IV.

Box Kiln Record for the foregoing cuts of Shoe Last Blocks, Dried by the use of exhaust steam during working hours only. Time 23 days. Allowed to cool down 4 days more before opening kiln.

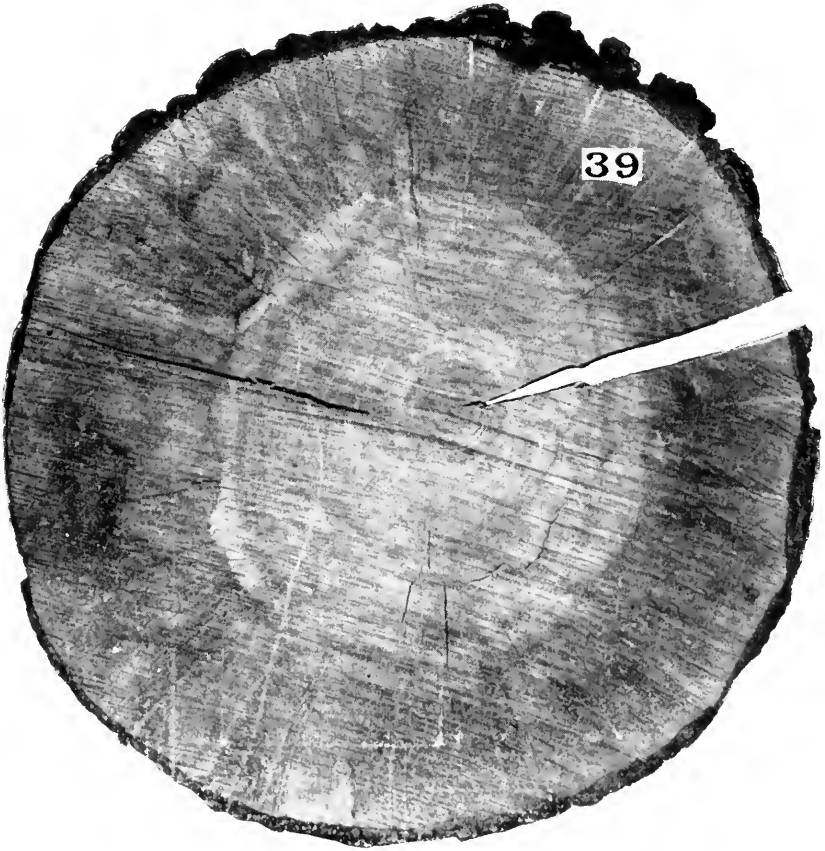


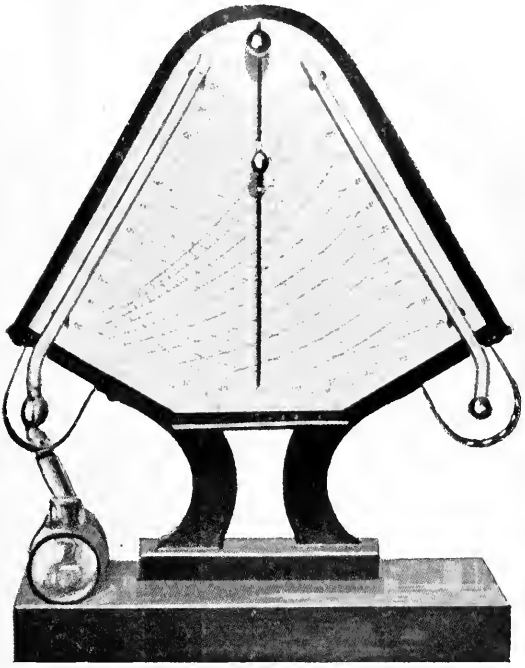
Plate 8

	Time Test was Made	Spray	Coil	Damp Air	Fresh Air	Degree Wet Bnlb	Degree Dry Bulb	Per cent. Humidity
A. M.	5.00	1	1	F	¼	105	120	60
P. M.	8.00	1	1	F	¼	110	120	70
A. M.								
P. M.	2.00	1	1	F	¼	125	130	90
A. M.								
P. M.	5.00	1	1	F	¼	120	120	100
A. M.	8.00	1	1	F	¼	100	100	100
P. M.								
A. M.								
P. M.	5.00	½	½	F	¼	110	120	70
A. M.	8.00	½	½	F	¼	115	130	60
P. M.	5.00	0	2	F	¼	110	120	70
A. M.	8.00	0	2	F	¼	110	120	70
Noon		1	2	F	¼	110	120	70
Noon		0	2	F	¼	110	120	70
A. M.	8.00	0	2	F	¼	105	110	60
P. M.	7.00	0	2	F	¼	110	120	70
A. M.	8.00	0	2	F	¼	110	120	70
P. M.	7.00	0	2	F	¼	110	120	70
A. M.	8.00	0	2	F	¼	110	120	70
P. M.	7.00	0	2	F	¼	115	120	90
A. M.	8.00	0	2	F	¼	114	120	80
P. M.	7.00	0	2	F	¼	120	130	70
A. M.	8.00	0	2	F	¼	120	130	70
P. M.		0		F	¼	110	120	70
A. M.	8.00	0		F	¼	115	120	80
P. M.		0		F	¼	95	100	60
A. M.		0		F	¼	100	110	70
P. M.		0		F	¼	110	130	50
A. M.	8.00	0	2	F	¼	115	120	60
P. M.		0	2	F	¼	115	120	80
A. M.	8.00	0	2	F	¼	100	120	45
P. M.		0	2	F	¼	94	120	37
A. M.		0	2	F	¼	.98	120	45
P. M.								
A. M.		0	0	F	¼	85	115	45
P. M.								
A. M.		0	0	F	¼	.85	115	45
P. M.		0		F	¼	85	115	45
A. M.		0	0	F	¼	.95	110	45
P. M.								
A. M.		0	0	F	¼	90	110	45
P. M.		0		F	¼	.95	100	45

Box Kiln filled with air dried Maple blocks, 4" x 5" x12" long and operated as above produced perfectly dried blocks.

CHAPTER IV

DIRECTIONS FOR READING LLOYD'S HYGRODEIK



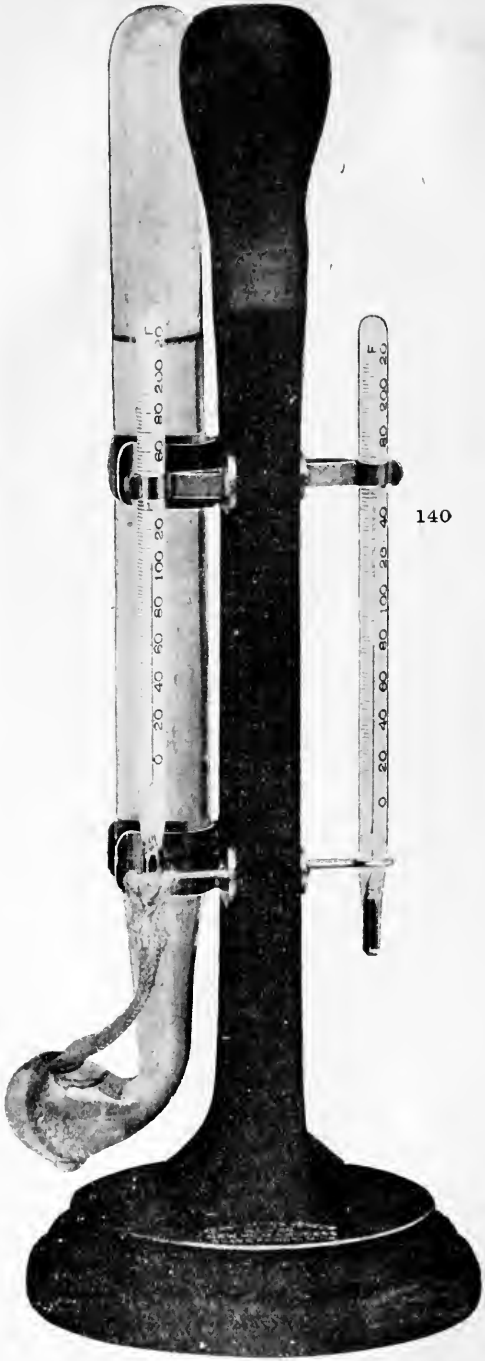
Hygrodeik

Catch the reading of the wet bulb first, and with this in mind quickly catch the reading of the dry bulb. Swing the arm towards the wet bulb, and set the sliding pointer to the degree reading on the wet bulb. Then swing the arm to the right until it intersects the lines running with a downward curve from the reading on the dry bulb scale, from the point of intersection. Notice the end of the swinging bar passes along the lower set of figures. This scale represents the humidity in percentages.

Should the reading of the wet bulb thermometer be 120 degrees and that of the dry bulb be 140 degrees, the index hand will indicate relative humidity 53%, when the pointer rests on the intersecting lines of 120 and 140 degrees.

DEW POINT is 100%, or FULL CAPACITY OF AIR.

The curved column of figures represents the amount of water in grains contained in a cubic foot of air at the different temperatures. This is the full carrying capacity of the air, and is termed the Dew Point. That is if the Wet Bulb shows 140 degrees, and the Dry bulb 140 degrees, this would read 100% humidity, and carrying 57 grains to the cubic foot of air.



Humidograph

CHAPTER V

HUMIDOGRAPH

Instructions for Operating.

The HUMIDOGRAPH is a wet and dry bulb thermometer, the wet bulb being connected with a water bottle.

The HUMIDOGRAPH is a self registering instrument, especially designed for getting percentages of humidity, and it makes it possible to get the readings of the inside of the kiln at any point desired. The instrument is composed of two registering removable thermometers or bulbs, and is so constructed that it registers the degree of heat on one bulb, and the other bulb is arranged for registering humidity, by being inserted into a wick attached to the bottle containing water in which one end of its wick is immersed.

To operate this instrument, it is only necessary to remove the thermometer from the stand, and take it between the thumb and fore finger, and give it a sharp flirt with the wrist, which will throw the mercury a few degrees below the supposed temperature of the kiln. The instrument being very sensitive, it must not be shaken severely. .To apply the Humidograph fill a bottle with rain water and place the HUMIDOGRAPH in a place where it is desired to learn the humidity and temperature. As the place contains 100% humidity, both of the thermometers will register the same, and any percentages below this will be shown as a difference between the readings of the thermometers.

When the difference between the two thermometers is learned, refer to the table and see column of differences which runs from zero to sixty, inclusive. (See page 59). For example, if the wet bulb registers 140 deg. and the dry bulb 180 deg. there is a difference of 40 degrees. Look down the column of differences and find forty, and to the right of 40 you will find 33% (under 180), which indicates that there is 33% of humidity. By this means any % of humidity may be ascertained.

It is very essential, in operating this instrument, to keep a clean wick, and to use clean water—otherwise you will get imperfect readings.

HUMIDITY TABLE. The following table will give a fair idea of temperatures and humidities that work out

the best average results in drying by the vapor process.

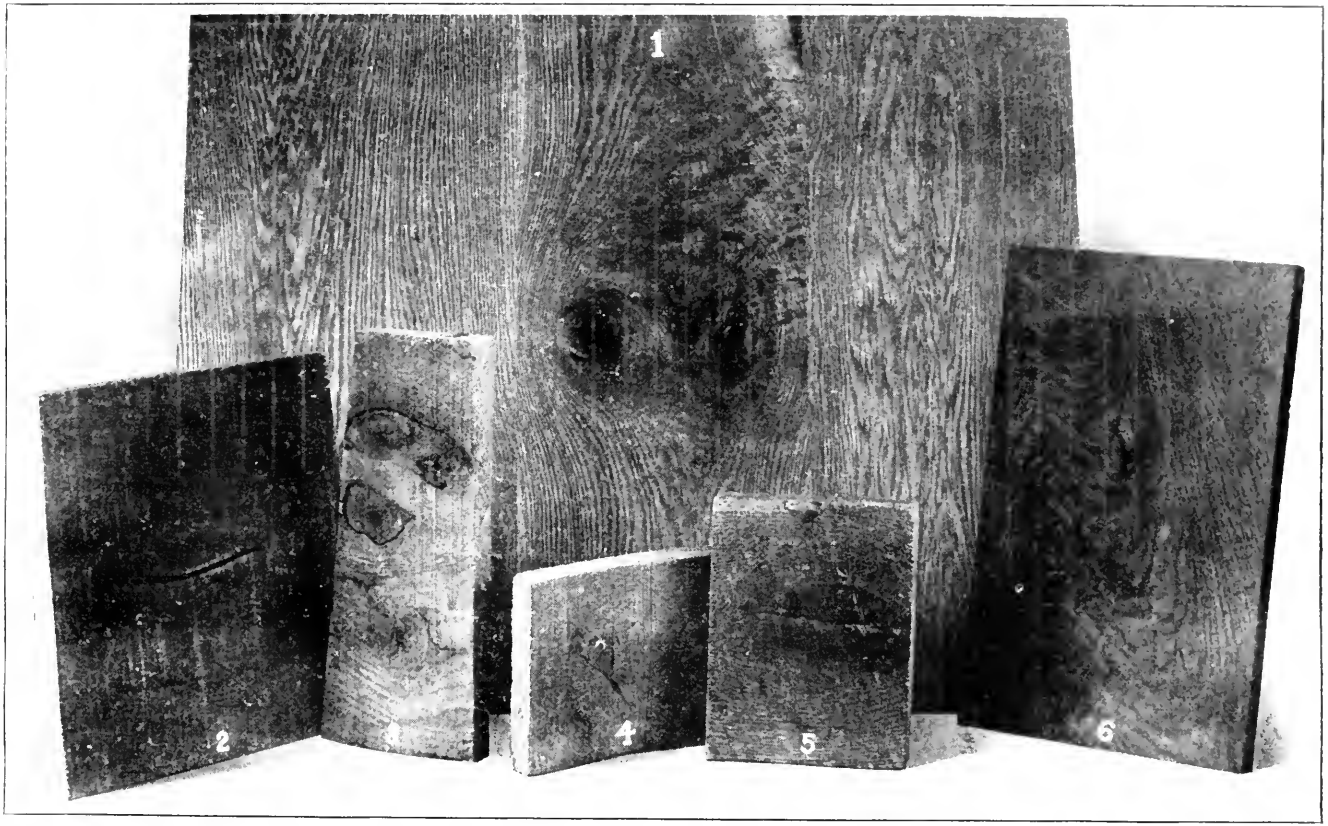
Green or Loading End		Dry or Unloading End	
Temperature	Humidity	Temperature	Humidity
120 deg	35%	140 deg	30%
130 deg	90	150 deg	35
140 deg	95	160 deg	35
150 deg	100	170 deg	40
160 deg	100	180 deg	40

High temperature and high humidity produce quick drying, i. e., 160 deg., 100% loading end, 180 deg., 35 to 40% unloading end.

The following table shows the number of grains of moisture that can be carried by one cubic foot of air at the different degrees of temperature, (atmosphere at a temperature of 80 deg. normal condition 50% carries about 5 grains of moisture to the cubic foot.) and the number of times greater power to dry than the atmosphere:

140 deg. car's 57 gr. 30% hum. car's 17+or 40 more gr.= 8 times force
150 deg. car's 72 gr. 30% hum. car's 21+or 51 more gr.=10 times force
160 deg. car's 90 gr. 30% hum. car's 27+or 51 more gr.=12 times foree
170 deg. car's 112 gr. 35% hum. car's 39+or 73 more gr.=14 times force
180 deg. car's 139 gr. 40% hum. car's 55+or 83 more gr.=15 times force

Showing that the humidity on drying lumber can be carried to 50% at 140 deg. and 80% at 180 deg. and still have five times greater power than the atmosphere under its best possible conditions.



Cut shows: Knots surfaced on No. 1 and No. 6. Knots in the rough Nos. 2-3-4-5. Planed down makes good filler for tops.

TIME TABLE FOR

Estimated probable time for drying 1" stock from 3 mos. to 12 mos. on sticks by the G.R.V.W. Process	DAS.	Weight per M. feet. GREEN	DRY
ASH (Black)	3-4	4,500	3,250
ASH (White)	5-7	4,500	3,000
BASSWOOD	3-4	4,000	2,400
BEECH	8-9	6,000	4,000
BIRCH	6-8	5,500	4,000
BUTTERNUT	3-4	4,000	2,500
CEDAR			
CHERRY	5-7	5,000	3,800
CHESTNUT	5-7	5,000	2,800
CYPRESS	4-6	5,000	3,000
COTTONWOOD	4-5	4,500	2,800
ELM (Soft)	4-5	4,500	2,000
ELM (Rock)	6-7	5,500	4,000
FIR			
GUM (White)		4,050	2,320
GUM (Red)	5-6	5,500	3,300
HEMLOCK			
HICKORY (Cut to Sq. Dim.)	6-8	6,000	4,500
MAHOGANY	5-6	4,500	3,500
MAHOGANY (African)			
MAPLE	5-7	5,500	4,000
MAPLE (White)	5-7	5,500	4,000
OAK (Plain)	6-9	5,500	4,000
OAK (Quartered)	6-7	5,500	4,000
PINE			
PINE White Norway			
PINE Long Leaf	3-4	4,300	3,200
PINE Short Leaf			
PINE Sugar			
POPLAR	5-7	3,800	2,800
SPRUCE			
SYCAMORE		4,750	3,000
VERMILLION	10-12	4,800	
WALNUT		4,800	3,800
WHITEWOOD	5-7	3,800	2,800

We desire to fill in the remainder comes to hand.

DRYING LUMBER

Time of drying 12 mo. stock by our patrons — 3 mos. on sticks — Time of drying green from saw

2/4	3/4	4/4	5/4	6/4	8/4	10/4	12/4	14/4	4/4	6/4	8/4	10/4	12/4	2/4	3/4	4/4	5/4	6/4	8/4	10/4	12/4	14/4
		4			11																	
		5																				
		4	6					11							8							
	7			9		17																
			10			17																
											7											
				7																		
					8																	
					6																	
		6		8	12																	
		5		8																		
				10	12		18															
				9	12																	
		4½			14		19		25							10						
			9½																			
		4½	8	10	12	21				10						9						
		6	8	10		17																
		4			5											3			4			
																4			5			
			7																			
				7/9	8/10											8						
		5																				
					11																	

of the squares as the information

HUMIDITY PER CENTAGE TABLE

READING OF TEMPERATURE OF DRY BULB THERMOMETER

DIFFERENCE IN DEGREES BETWEEN WET & DRY BULB

	180°	175°	170°	165°	160°	155°	150°	145°	140°	135°
GRAINS PER CU FT OF AIR	139	125	112	100	90	80	72.	64.	57.	50.
0	100	100	100	100	100	100	100	100	100	100
.5	99	99	99	99	99	99	99	99	99	98
1.	98	98	98	98	97	97	97	97	97	97
1.5	97	97	96	96	96	96	96	96	95	95
2.	96	96	95	95	96	95	95	94	94	94
2.5	95	95	95	94	94	94	94	93	93	93
5.	88	88	87	87	87	87	87	86	86	85
7.5	80	80	80	80	80	80	80	79	79	78
10.	77	75	75	75	75	75	74	74	73	73
12.5	70	70	70	70	70	70	70	68	68	68
15.	67	65	65	65	65	65	64	64	64	64
17.5	62	62	60	60	60	60	60	58	58	58
20.	58	57	57	57	56	56	56	54	54	54
22.5	55	53	53	53	53	53	52	52	52	49
25.	50	50	50	50	49	49	49	47	46	44
27.5	47	46	46	45	45	45	45	43	42	41
30.	45	43	43	42	42	41	40	39	38	37
32.5	42	40	40	40	39	39	38	37	36	34
35.	38	37	37	36	35	34	33	32	30	28
37.5	35	35	35	34	32	31	30	28	27	25
40.	33	33	32	31	30	28	27	26	23	22
42.5	31	30	30	29	27	26	24	23	21	19
45.	29	28	28	26	25	23	22	20	18	16
47.5	27	26	25	24	23	21	20	17	16	13
50.	25	24	23	22	20	18	18	15	13	11
52.5	23	22	20	20	18	17	15	14	11	10
55.	21	20	19	18	16	14	13	11	9	7
57.5	19	18	17	16	14	12	11	9	7	5
60.	18	17	17	15	12	10	9	7	5	

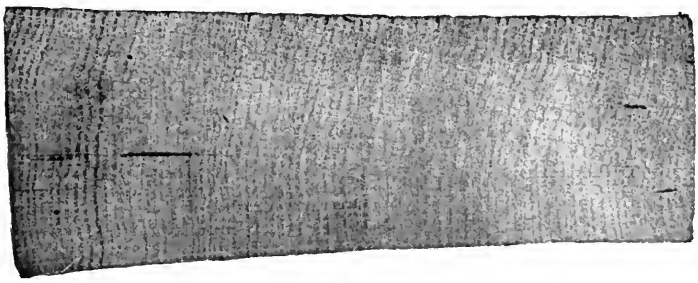
DIFFERENCE IN DEGREES BETWEEN W. & D. BULB

	130°	125°	120°	115°	110°	105°	100°	95°	90°	85°	80°
GRAINS PER CU FT OF AIR	44.	39.	34.	30.	26.	23.	19	17.	15.	13.	11.
0	100	100	100	100	100	100	100	100	100	100	100
.5	99	99	99	99	99	99	99	99	99	99	99
1.	97	97	97	97	97	97	96	96	96	96	96
1.5	95	95	95	95	94	94	94	93	92	92	92
2.	94	93	93	93	92	92	91	91	90	90	90
2.5	92	92	92	92	90	90	89	89	88	87	87
5.	85	85	85	85	83	82	82	80	80	80	80
7.5	78	78	78	78	76	75	74	72	71	71	71
10.	73	73	73	73	69	67	66	65	64	64	62
12.5	68	67	67	67	62	62	58	58	57	55	55
15.	62	62	62	62	56	55	55	53	50	47	43
17.5	58	57	57	57	50	47	47	45	45	45	43
20.	53	53	50	50	45	43	43	40	37	35	29
22.5	49	48	48	46	40	38	38	34	29	26	21
25.	43	42	40	40	36	33	30	27	24	20	17
27.5	40	38	37	37	33	32	27	25	21	15	10
30.	36	34	33	32	28	25	23	19	15	10	5
32.5	32	29	26	23	21	18	15	12	9	6	
35.	27	24	22	20	20	17	14	9	5		
37.5	23	21	18	16	14	11	8	5			
40.	20	18	16	12	10	8	5				
42.5	17	15	12	9	8	5					
45.	14	12	10	8	5						
47.5	11	9	7	5							
50.	9	7	5								
52.5	7	5									
55.	5										

1 Lb = 7000 Grains

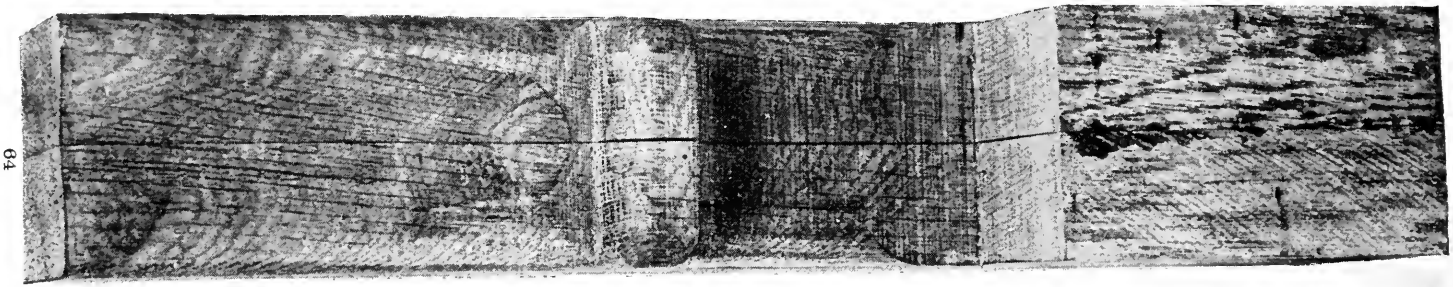
These cuts show conditions often found in Lumber as it comes from the lumber yard

The above cut shows a section taken from a table top in which a piece of air dried white oak was placed between two pieces of properly kiln dried white oak, all $1\frac{3}{4}$" thick, faced on both sides with $\frac{1}{16}$" basswood, veneered and mahogany faced. The shrinkage shown in the center was the result of about ten months exposure to the atmosphere in a closed room, showing, conclusively, that properly kiln dried lumber retains its exact proportions under all conditions, while air dried or improperly kiln dried lumber is not at rest, but is continually changing its form and proportions. This center piece would have been as thick as the edge pieces had it been through the vapor process.



2 inch Quartered Oak

2 inch Plain Oak

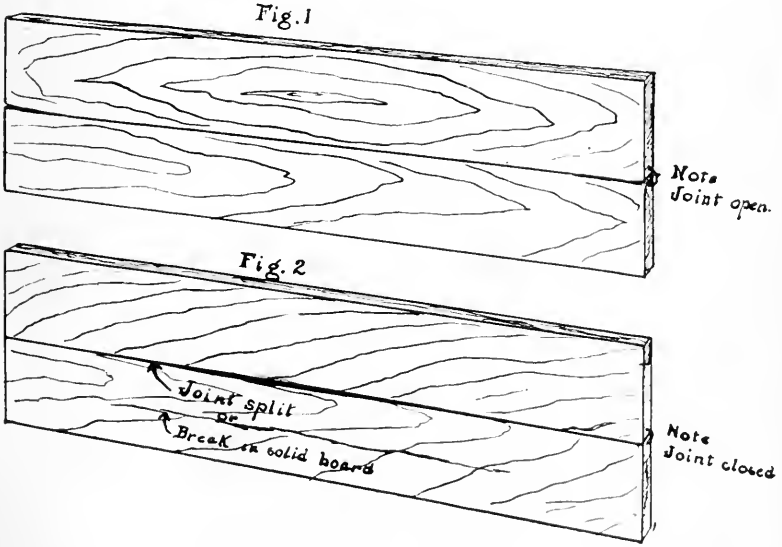


Chair Leg Section. Built up from two pieces of $1\frac{1}{4}$" x $4\frac{1}{2}$" quarter sawed white oak, thoroughly glued. Several days later it was noticed that the glue joint was opened in the center of the leg, while 4" at each end remained perfectly glued.

Glue Joint Diagram

Fig 1. Represents what happens when lumber is not dry enough. Notice the joint is broken from 3 to 5 inches at each end. Ends have shrunk.

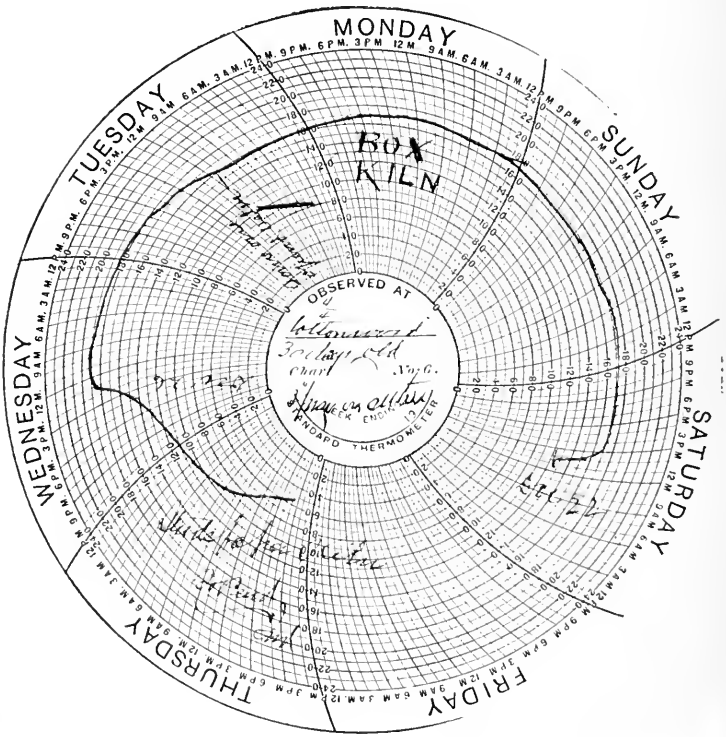
Fig 2. Shows what would be likely to happen, and does frequently happen, and it is supposed that the lumber is not dry enough, and it is given another warming up in the kiln, whereas the real difficulty is the lumber is so very dry that it is absorbing all the moisture from the air and expanding with tremendous force, so much so, that if a $\frac{3}{8}$" length of grain were cut off across this board 3 or 4" from the end, it would immediately jump out beyond the width from whence it was cut— try it —. Notice the board splits through the joint while the ends remain glued, or there is a break in the solid board nearly it's length. Showing great danger in over drying — Don't-do-it.

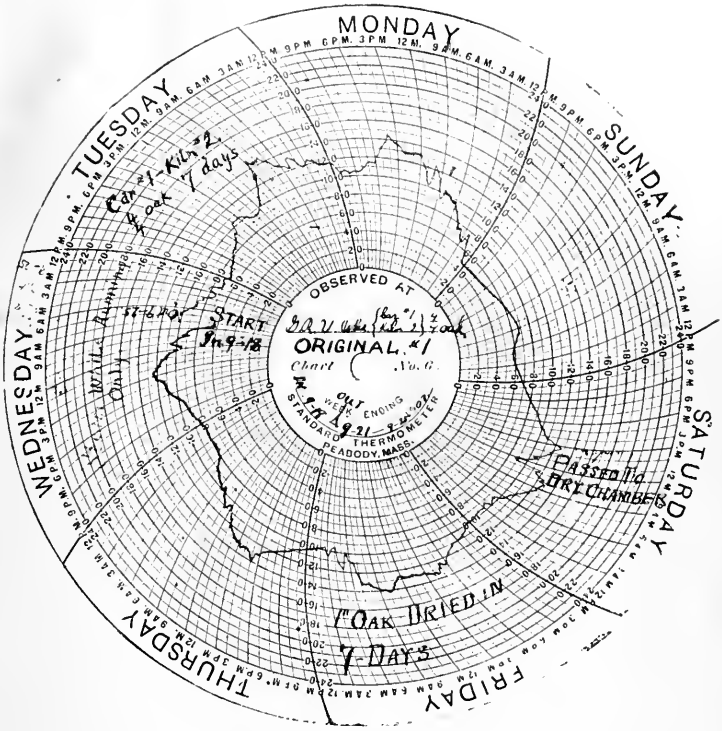


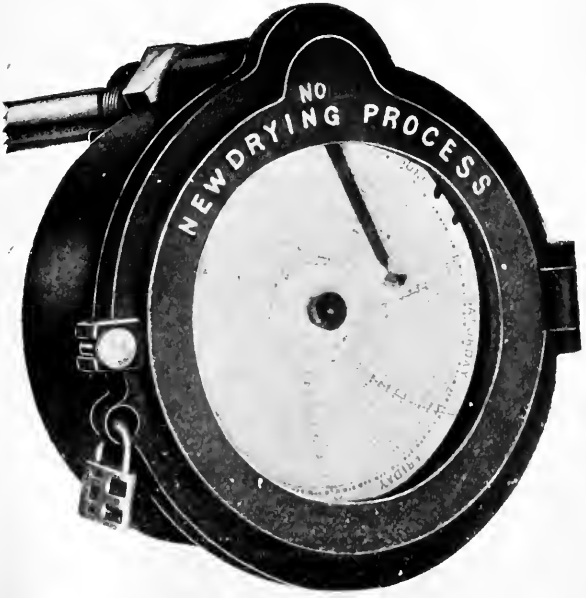
RECORDING THERMOMETER

The Recorder notes upon its dial the slightest change in temperature. These dials are arranged for making a run for 7 days to the full circuit of the dial, and are designed to be changed weekly, making a continuous reading. These records are valuable as sentinels guarding the interests of the manufacturer, day and night.

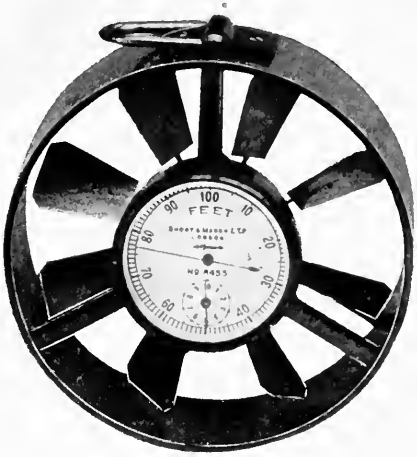
The Weather Bureau, in forecasting the weather, employs certain instruments for specific purposes, among which are the recording thermometer, Humidograph, Hygrodeik, Anemometer and Barometer.




MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
OBSERVED AT
ORIGINAL
Chart No. 6
STANDARD THERMOMETER
PEABODY, MASS.
"OAK DRIED IN
7 DAYS"
PASSED To DRY CHAMBER
START
Car #1 - Kiln #2
Oak 7 days
Daily
Walk Aluminum
11-6 hr


NO
NEW DRYING PROCESS

The Recording Thermometer records the changes in the temperature. The Humidograph has a dry bulb which registers the highest degree of temperature, and a wet bulb registering a different reading indicating the humidity in the atmosphere. (See Humidograph, page 57). The Hygrodeik indicates the highest degree of temperature, and the wet bulb registers the difference in degrees—this difference is readily reduced to percentage. (See Hygrodeik, page 55).

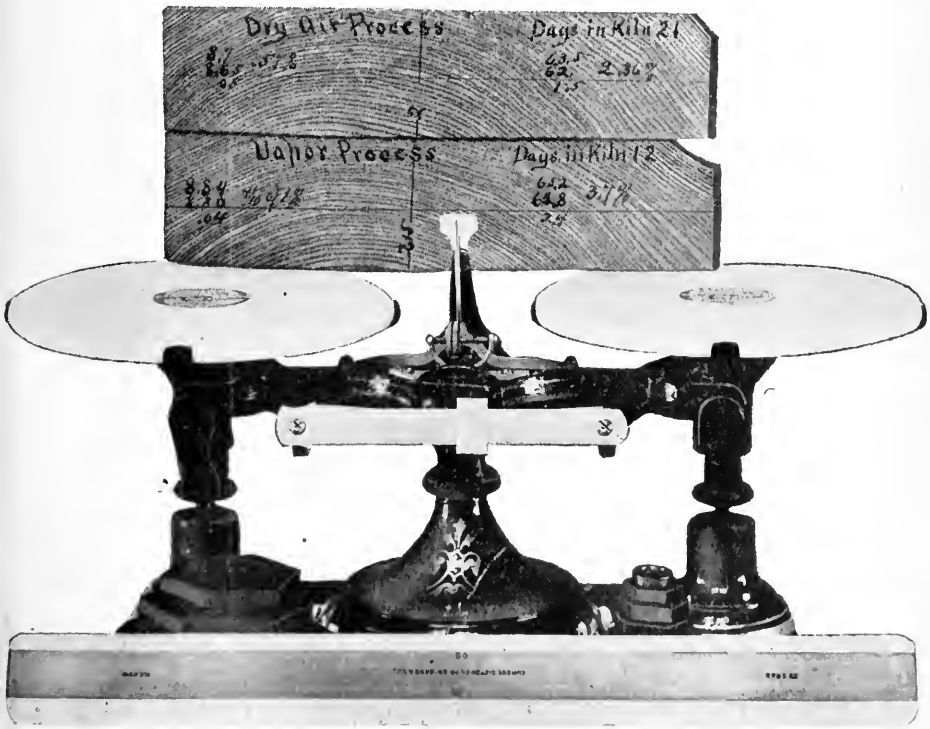


The Anemometer denotes the velocity of the air or wind currents in feet per minute or miles per hour, thus indicating pressure in pounds per square foot.

The Barometer indicates the atmospheric pressure produced by conflicting or opposing currents of air, and is not apparent to the sense of sight or touch, but is observed by the action of the pointer as it traverses the scale, indicating inches of pressure. It seldom remains at rest more than a few hours at a time, thus showing the great need of a reserve of power on a ventilating system in order to produce uniform results. With these facts and instruments in mind, it will be apparent that these same instruments are equally indispensable to the successful operating of a Dry Kiln.

The cut below represents a pair of balance scales used for weighing the test pieces, which is particularly nice in the adjustment of the weight along the bar, weighing to the one-tenth of a gram, doing away with exceedingly small weights, and is a great relief to the operator, while engaged in working out the percentages by weight.

This cut also shows a 2″ boxwood rule with celluloid facing with rulings of tenths and fiftieths to the inch. These celluloid facings are set upon the angular edges of the rule, making it possible to get very close readings for working out the percentages of shrinkage.



The two pieces on the scales are pieces of the same plank dried under different processes. Notice the dimensions.

Date_____

From_____

_____

Manager_____ Superintendent_____

Describe on this sheet the new dry kiln you desire, or your kiln to be remodeled to improve its output, filling in replies to the following list of questions, ANSWERING THEM CORRECTLY AND FULLY.

GIVE NUMBER AND SIZE OF KILNS TO BE BUILT OR REMODELED.

KILN BUILDING

1 No.....Length.....ft. inside of end walls. Width.....ft. between walls. Height.....ft. from top of rail to ceiling

2 No..... " ..... "

3 No..... " ..... "

4 What is name of kiln.....; When built.....; Who installed it.....

5 Is loading end North.....; East.....; South.....; or West .....

6 What is foundation material.....; How thick.....; Depth below rail line.....

7 Is building brick.....; Walls solid or hollow.....; If walls have flues in them.....

8 Is building cement .....; Walls solid, hollow or blocks.....; sketch same on back of this sheet

9 Is building wood.....; Size of studs.....; C. to C.....; Lining.....; Siding.....

10 Stories high....., If more than one describe fully.....

11 Is ceiling wood.....; No. of layers.....; Thickness.....; Condition.....

12 Is roof concrete.....; How thick.....; How built..... and covered.....

13 Are doors wood.....; How hung.....Opening, Up or Sideways.....

14 Are doors canvas.....; Weight per yard.....; Single or double.....

CARS

15 How many loaded cars can stand at loading end.....; Unloading end .....

16 Is there a transfer track at loading end.....; Unloading end .....

17 How many cars does kiln hold.....; How long are bunks.....; Whose make.....

18 How much lumber on each car.....; Height of load from track to top of load .....; Wide.....

LUMBER

19 How many cars do you dry daily.....; How many do you want to dry.....

20 Does lumber enter kiln crosspiled.....; or endwise.....; No. stickers used.....

21 When kiln is full, how much space from end cars to doors.....; Between cars to sidewalls.....

22 Give AMOUNT OF EACH KIND OF LUMBER you wish to dry daily.....

.....

23 Give thickness of the above.....

.....

24 How long are dried.....Or fresh from saw.....; What is the longest length.....

POSTS and RAILS

25 What are the rail supports, piers or posts .....; What distance from Center to C. .....; Height.....

26 How many rails .....; Weight per yard....; What distance from Center to C..... Grade of track in 10 ft. .....

27 Distance bottom of rail to bottom of kiln at loading end.....; Unloading end .....

COIL

28 Distance bottom of rail to top of coil.....; Distance from coil to sidewalls.....

29 Distance from header to wall at loading end.....; Distance from end of coil to wall at unloading end.....

30 GIVE NUMBER of PIPES IN COIL .....; SIZE.....; LENGTH .....; Total lineal ft.....

31 Are headers cast or pipe .....Diameter .....; Length .....; Horizontal or vertical.....

32 Are headers for 1-2-3 or 4 layers of pipe .....; Distance Center to Center of pipe in headers.....

33 Are holes in drip header threaded left hand .....; Or unions in coil.....; Where located.....

Steam Supply and Temperature

34 Size of supply pipe at header .....; Size of drip mains from headers.....

35 Do you use exhaust steam .....; What back pressure .....; Live steam.....; Pressure .....

36 Give size of exhaust pipe .....; Distance engine to kiln .....; Size live steam pipe .....

37 Give temperature now carried loading end .....; Unloading end .....

38 Have you a recording thermometer .....; What make .....; Pressure regulator .....; What make.....

39 Size engine cylinder. .....; Rev. per minute .....; Point of cut-off.....; H. P.....

40 Size and H. P. of boilers.....; Pressure carried .....; Fuel used .....

41 What boiler compound used.....; What feed water heater .....; Open or closed.....

42 Does all exhaust pass through heater before going to kiln.....; If not, what portion does .....

DRIP SYSTEM

43 Name of vacuum system .....; Size of pump .....; Name .....; Vacuum carried .....

44 Do drips return to a branch tee header at the pump .....; If not, how connected .....

45 Do any live steam drips return direct to pump .....; Or through trap to pump.....

46 Does your factory require the greater part of your exhaust during winter months .....; Give proportion .....

47 Number of traps now used on your kilns .....; Capacity.....; Name.....

48 How high are kiln drips above pump or trap? .....; or how far below.....

49 If no vacuum system, how are drips provided for .....

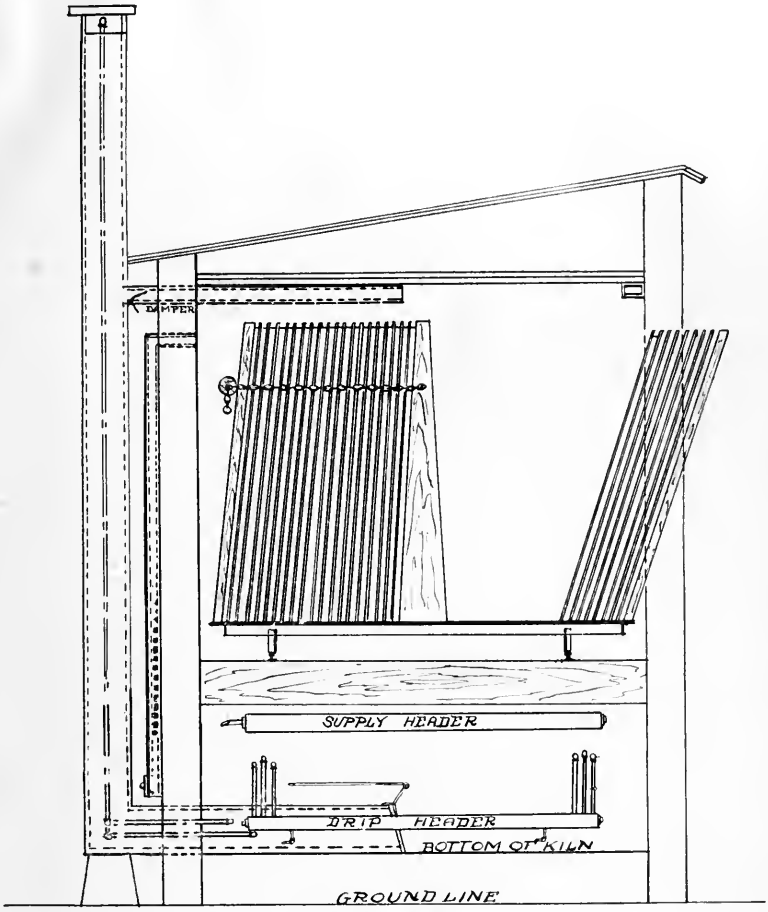
50 .....

PENCIL an outline PLAN of Kiln and Buildings adjoining or near by, approximate distance between and height or number of stories high of these surrounding buildings on BACK of this sheet. Scale is not necessary, but dimensions and distances are.

If you have drawings of kiln, send them to us and we will return them promptly. If you have no plans, send us a sketch showing plan, end and side elevations, coils and location of mains and drips. This will enable us to make accurate drawings of your kiln and estimates on the cost of the equipment.

Give Us Plain Answers to All Questions, Written in Ink.

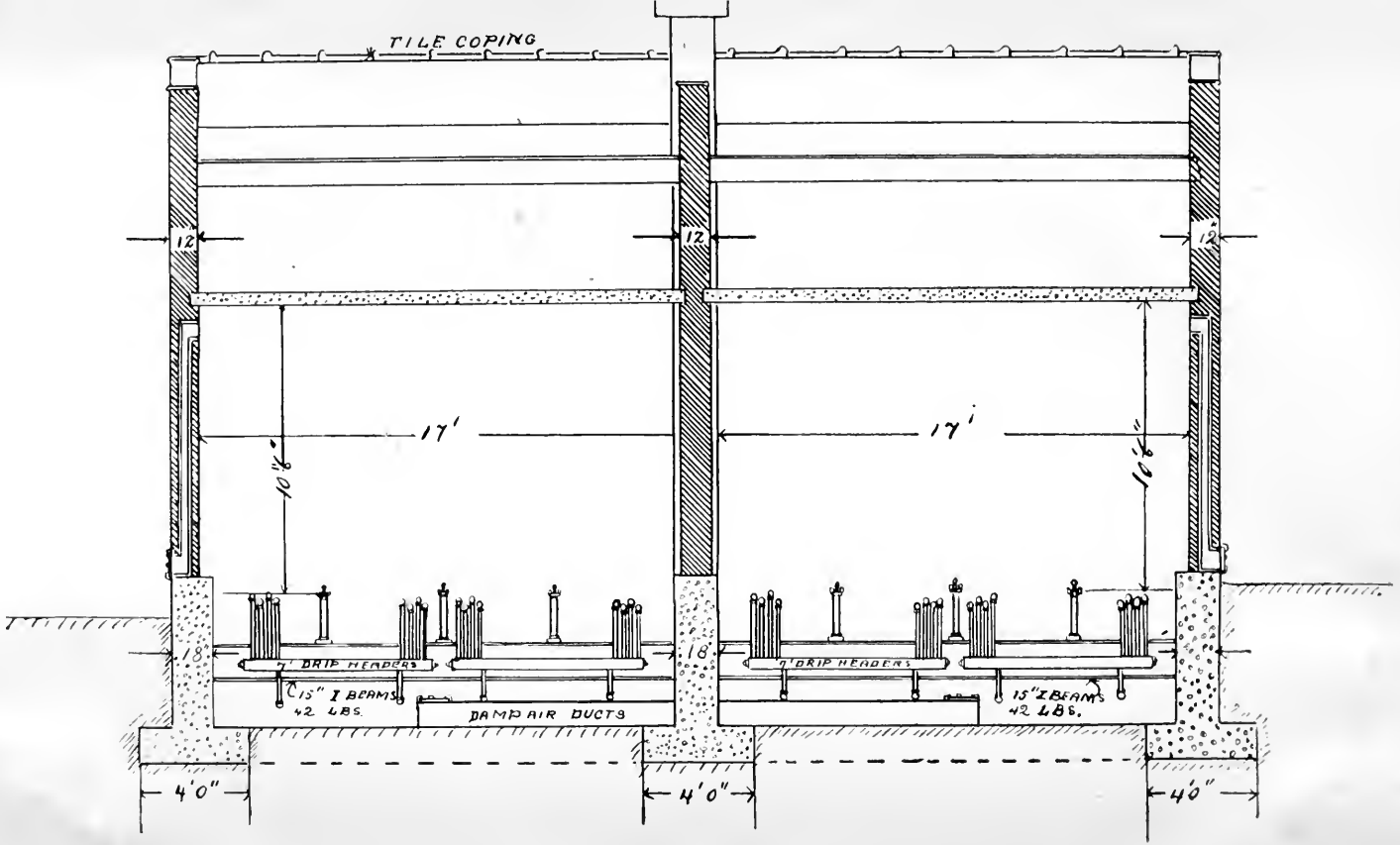
Signature._____



BOX KILN

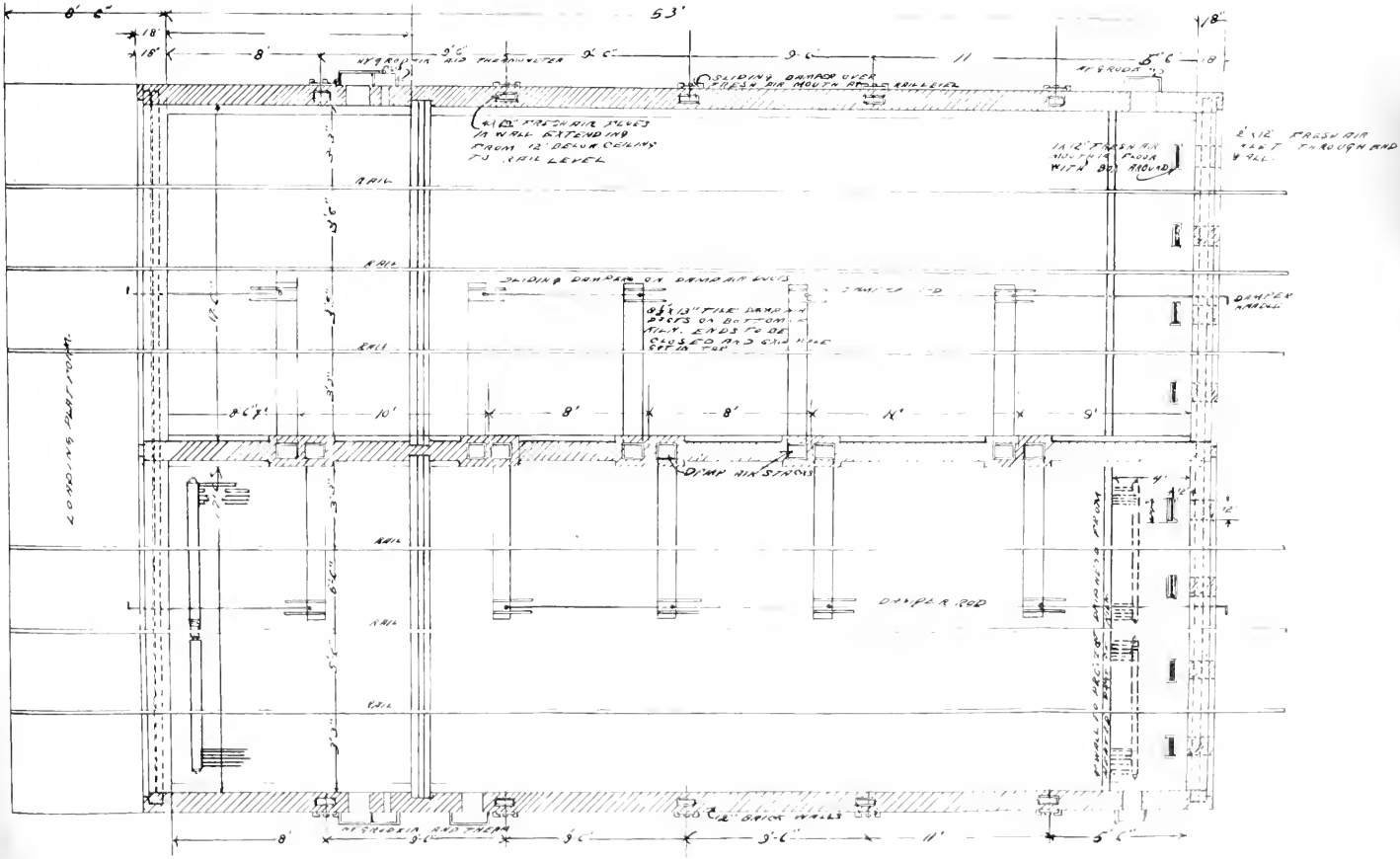
Plate VII

The kiln represented above dries ¼" Poplar Veneers, direct from the log, edge piled in finger racks, as indicated using 15 pounds pressure of live steam from 6:00 P. M. to 5:00 A. M., the spray being used heavy for the first two hours only, with the coil on and dampers closed. At this point, open the bottom dampers half way until 5:00 o'clock in the morning, then shut the steam off from the coil, but allow it to remain on the stack equalizer at the same time open the dampers in the top flues so as to draw off the humidity from the top of the kiln—thus removing the surface moisture and allowing the veneers to cool down before exposing them to the atmosphere.



UNLOADING END ELEVATION

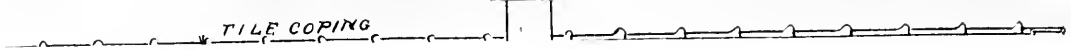
Plate VIII



GENERAL PLAN

SCALE 1/4"=1'-0"

Progressive Kiln Plate IX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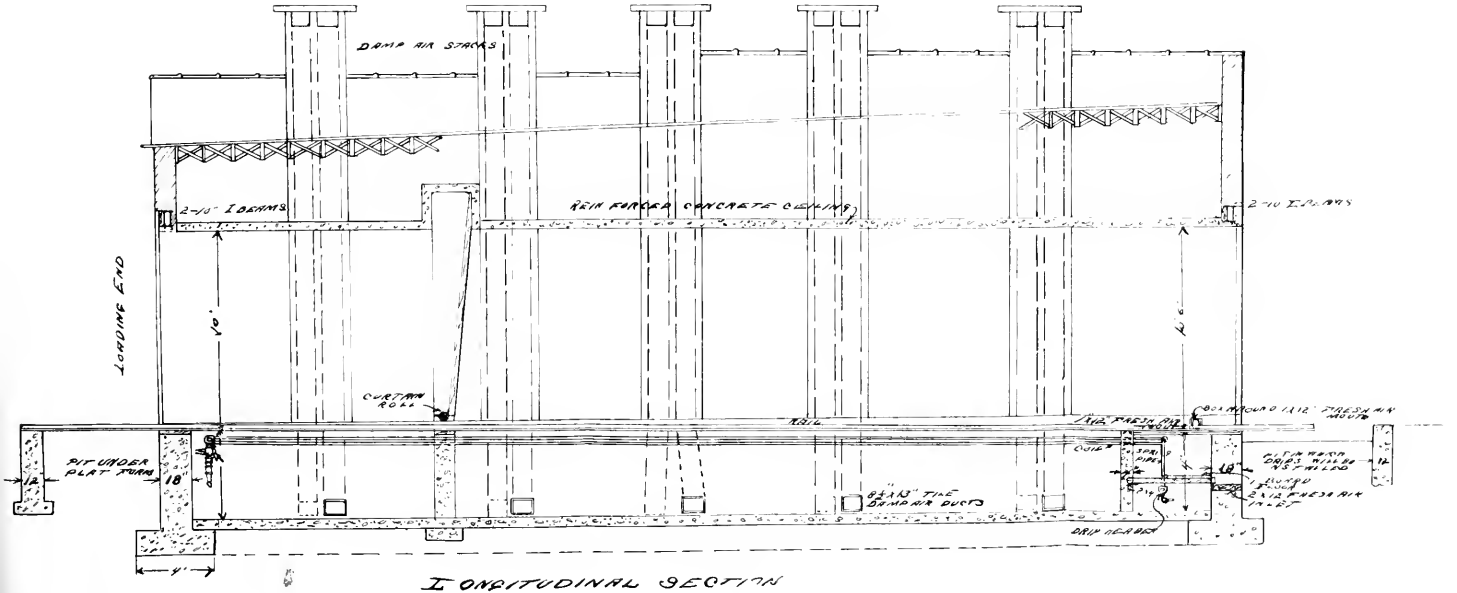
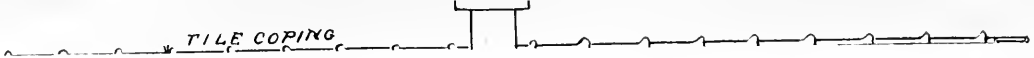


LONGITUDINAL SECTION

Plate X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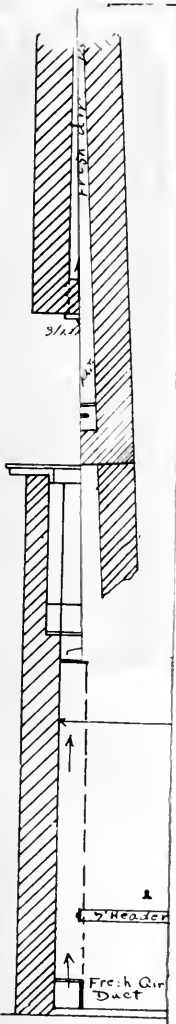
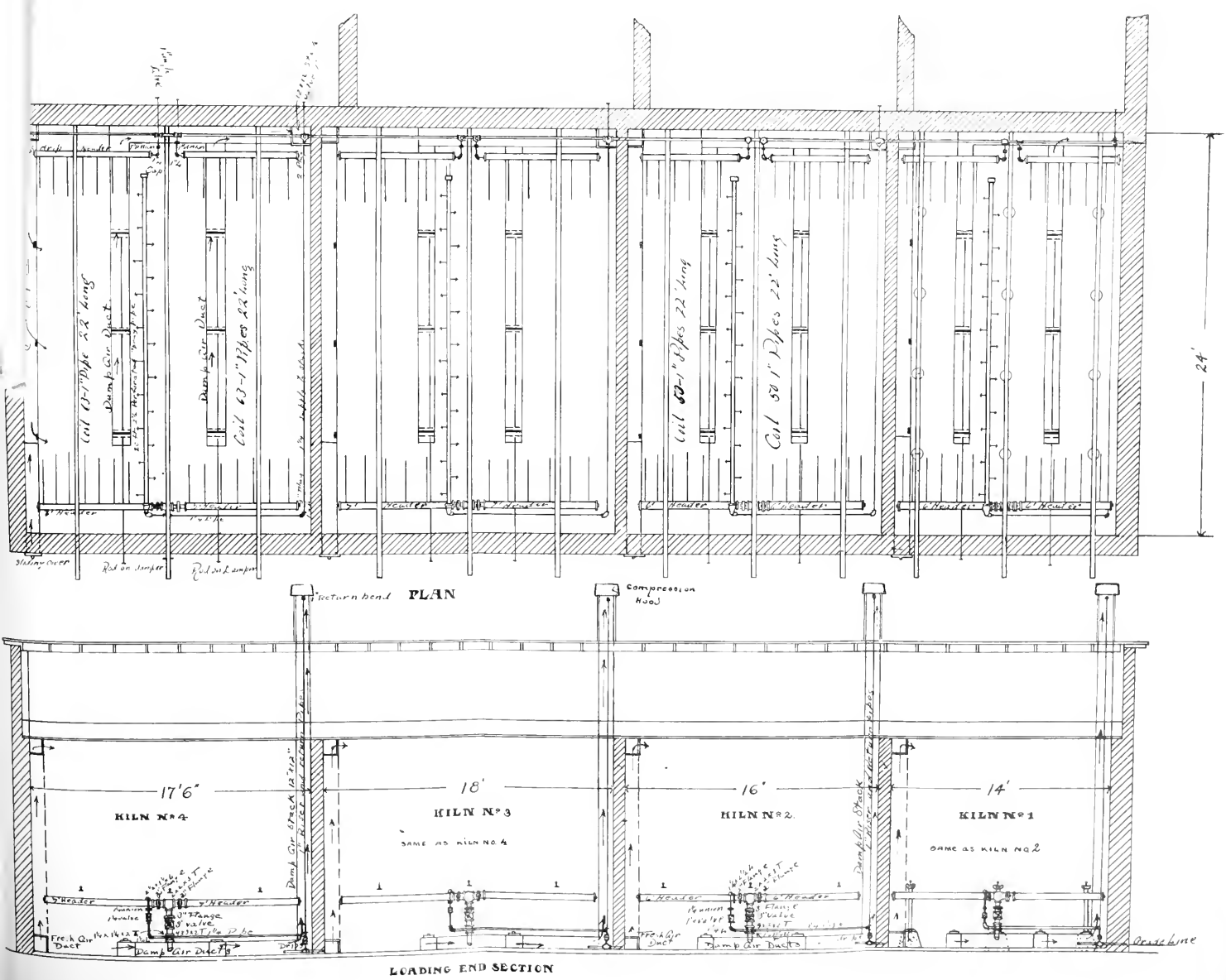
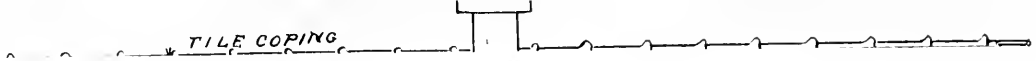

Fresh Air
3/4"
Fresh Air
Duct



BOX KILN

Plate X I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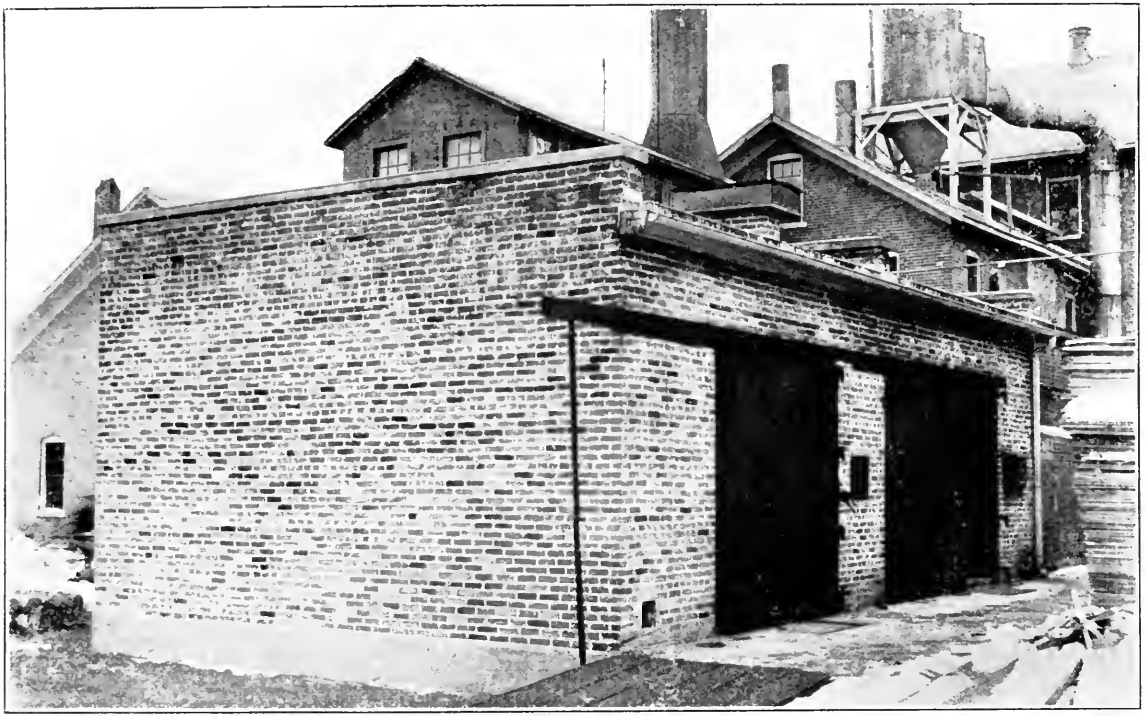

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